ASTRONOMY

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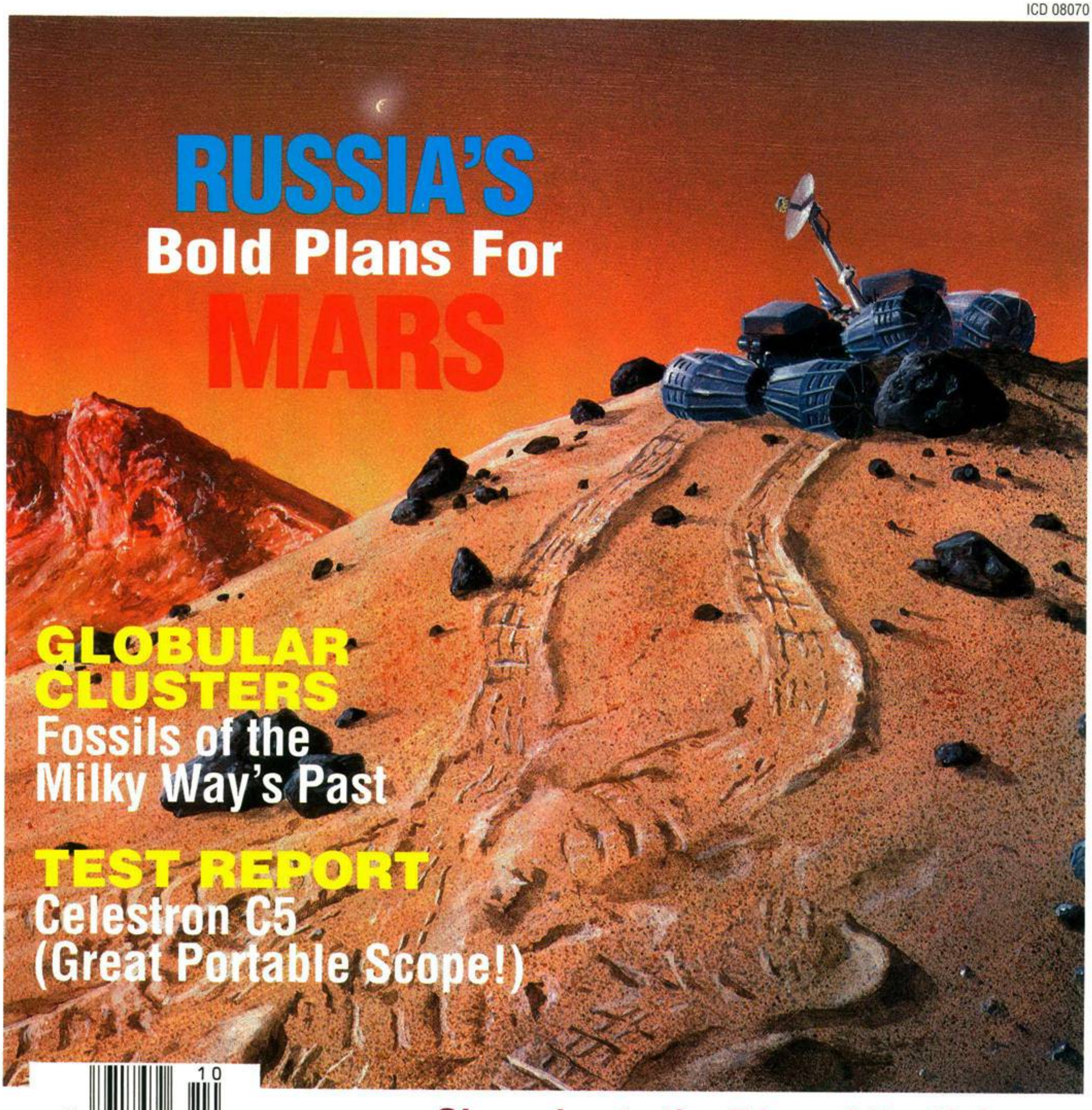

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Supplied complete per catalog specifications*:

8" LX200 Schmidt-Cassegrain	**$2295.**
Equatorial Wedge 8"	**110.**
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Packing and shipping in the 48 states: 8"—$105; 10"—$145

■*All prices shown are suggested USA mail-order retail prices, exclusive of sales taxes or credit card charges, if applicable.

■For dealer or catalog information see the Meade **ED Apochromatic Refractor** ad in this issue.

Meade 10" LX200. Shown with optional Superwedge.

Meade 8" LX200. All features shown are standard equipment.

LX200 SCHMIDT-CASSEGRAINS

The largest-selling serious telescopes in the world.

Now you can buy the most advanced 8" and 10" Schmidt-Cassegrains ever produced, at a price directly competitive with other SCT's offering only a fraction of the features!

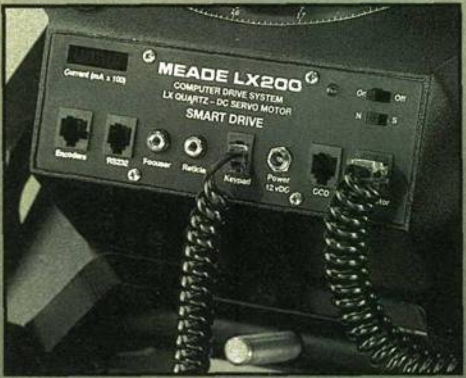
Meade LX200 SCT's offer a revolutionary departure from any other SCT's ever made available. Consider the **standard specifications** of these telescopes:

New Heavy-Duty Fork Mounts—The largest, most rigid in the industry. *Meade 8" and 10" LX200 fork mounts yield the lowest damping times of any SC fork mounts available.* Large 4"-diameter polar ball bearings complemented by DC-servo-motor-driven worm gears on ***both*** telescope axes permit observatory-level precision in tracking, guiding, and slewing.

100% Computer-Controlled Operation—All-new Meade LX200 microprocessor-controlled drive systems offer an incredible array of features:

■**Four-speed operation on both telescope axes** simultaneously, including (a) photo-guiding (at **2x** sidereal rate); (b) image centering and microslewing in the main telescope (at **32x** sidereal rate); (c) image centering in the view-finder (at **2**° per sec.); or fast-slew of the main telescope across the skies (at **8**° per sec.).

■**Pushbutton Electric Slew**—Press RA or Dec slew, east or west, north or south, and the telescope moves at 8° per sec. on both axes. As you near a desired object, flip to 2° per sec. slew, to center the object in the field. The observer need never touch the telescope in moving from one object to another. (Of course, if you wish, the telescope may be moved manually as well.)



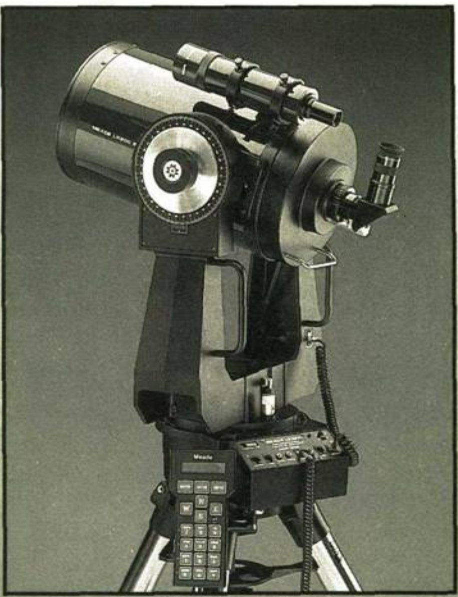
■**Digital Readouts** on both axes, read from the handheld Electronic Command Center (ECC).

■**GO TO Capability**—Enter the RA and Dec of an object into the keypad of the ECC, press GO TO, and the telescope automatically slews to the object at 8° per sec., centering it in the field.

■**747-Object Built-in Library**—Enter any of the 110 Messier objects, 278 of the finest NGC objects, 351 stars (doubles, variables, polar reference stars), or one of the 8 planets, from Mercury to Pluto, press GO TO, and the telescope slews at 8° per sec. to the object with uncanny precision. For $99* add the 8000-object Meade CNGC library, a 30-second plug-in.

■**Permanently programmable (PPEC) Smart Drive**™, capable of reducing periodic drive errors to 5 arc. sec. or less.

Legendary Meade Super Multi-Coated f/6.3 or f/10 Schmidt-Cassegrain Optics—Now you can choose either wide-field f/6.3 or classical f/10 Meade US-made SC optics **at the same price.** Either way, you'll be buying the finest Schmidt-Cassegrain optical system available, a system that yields razor-sharp stellar images and high-resolution observing of the Moon, planets, and deep-space, from the World's leading manufacturer. Meade exclusive Super Multi-Coatings on both sides of the correcting plate assure maximum light transmission and contrast.



Altazimuth Mode Operation—For all visual observing applications, and for lunar and planetary photography, Meade LX200's may be set up in the altazimuth mode, without any equatorial wedge—just attach the telescope's drive base directly to the tripod, use the fast 1-star alignment procedure, and the telescope's computer actuates 2-axis tracking that keeps objects precisely centered in the field, even at high powers, during the entire observing session. For long exposure photography (longer than about 5 minutes) altazimuth-induced field rotation requires an equatorial wedge, which may be purchased separately.

Fast Polar Alignment—Center two reference stars in the telescopic field and the telescope's computer tells you exactly what telescope controls to actuate for precise polar alignment in the equatorial mode in less than a minute.

The widest array of keypad and power-panel control functions—In addition to the microprocessor-controlled operations listed above, the handheld ECC and the telescope's power panel permit: readout of sidereal or local time; actuation of the optional electric focuser; crossline brightness control of an illuminated reticle eyepiece; direct plug-in of popular CCD autoguiders/imagers; and more than 14 other telescope functions.

MEADE LX100 SCHMIDT-CASSEGRAINS

Observers not requiring the sophistication of the LX200 electronics may wish to consider an 8" or 10" LX100 model SCT instead. Meade LX100's include the exact same heavy-duty fork mounts of their LX200 counterparts, but with a microfine declination tangent arm control in place of the LX200's motorized worm gear, and with a 2-speed drive in place of the LX200's 4-speed drive; optical tubes and coatings are identical. Standard LX100 features include:

■ Handheld Electronic Command Center—With 2-speed operation, **2x** for photo-guiding and **32x** for image centering and microslewing in the main telescope. (With the optional DC-servo declination motor installed, these speeds are operational on both telescope axes.)

■ Permanently programmable (PPEC) Smart Drive, as described above.

Complete LX100 and LX200 Telescopes

Specifications: 8" and 10" LX200's—Each complete telescope includes: 8" or 10" SC optical tube assembly (specify f/6.3 or f/10) with super multi-coatings; heavy-duty fork mount, with 4" polar ball bearing, dual-axis 5.75" worm-gears, and multi-function power panel display on the drive base; manual slow-motion controls on both axes; handheld keypad Electronic Command Center, with digital readout display, PPEC Smart Drive, four-speed drive control on both axes, GO TO controller, and 747-object software library; 25 ft. power cords for telescope operation from either 12 v. DC auto cigarette lighter plug or 115v.AC; 8 x 50mm viewfinder with crosshairs; diagonal prism (1.25"); Series 4000 Super Plössl 26mm eyepiece; variable-height field tripod; new deluxe die-cut-foam-fitted carrying case; complete operating instructions.

Specifications: 8" and 10" LX100's—Each complete telescope includes 8" or 10" SC optical tube assembly (specify f/6.3 or f/10) with super multi-coatings; heavy-duty fork mount with 4" polar ball bearing, 5.75" RA worm gear, and multi-function power panel display on the drive base; manual slow-motion controls on both axes; handheld pushbutton Electronic Command Center with PPEC Smart Drive and 2-speed drive control; 25 ft. power cords for telescope operation from either 12v. DC auto cigarette lighter plug or from 115v. AC; viewfinder: 6 x 30mm (8") or 8 x 50mm (10"); diagonal prism (1.25"); Series 4000 Plössl 26mm eyepiece; variable-height field tripod; equatorial wedge (8") or Superwedge (10"); new deluxe die-cut-foam-fitted carrying case; complete operating instructions.

For the beginner, or for the most seasoned observer, Meade LX200's are the most user-friendly telescopes ever manufactured. First-time telescope users **almost uniformly** remark that "I saw **hundreds** of deep-space objects my very first night out!" Advanced amateurs report that "the LX200 found objects during my first observing session that I was unable to locate in over 20 years of serious observing with other telescopes."

Contact your authorized Meade dealer today. See for yourself why Meade LX200's are the largest-selling serious telescopes in the world.

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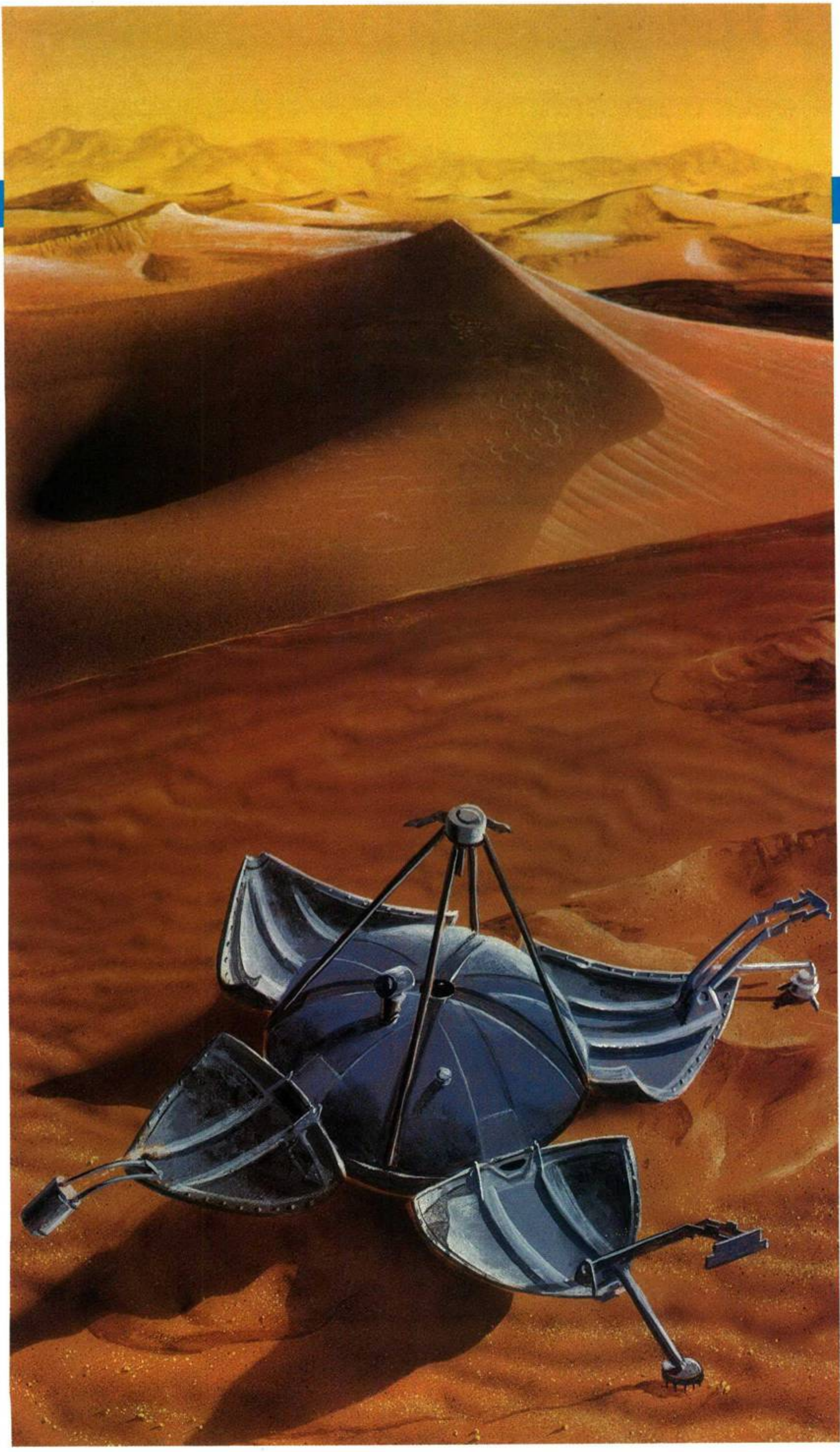
FOLLOWING IN VIKING'S FOOTSTEPS, a lander from Russia's Mars '94 mission probes the rust-colored Martian soil.



Michael Carroll

ON THE COVER: Roving the ruddy surface, a Russian probe examines the wind-swept dunes of Mars. The rover is just one of several instruments Russia will send to the Red Planet during the next three years. For more on these ambitious missions, see page 26. Illustration by Michael Carroll.

20th ANNIVERSARY YEAR

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The Audit Bureau

Behind the Scenes

OTHER SPACE PROGRAMS

It's a little startling to read about forthcoming Mars probes that will crawl, hop, soar, and slither across the Red Planet. It's an even bigger shock to realize these spacecraft aren't NASA's. They're Russian.

For over a third of a century, the world's other big space program has kept up a steady progress. From time to time political pressures drove it to create "spectaculars" that were more show than science. But underneath lay a solid record of achievement — all the more impressive given the constraints we now know Russian scientists and engineers have to work under. But with the planet Mars, bad luck has dogged the Russians right from the beginning.

Let's hope that's about to change. Our lead feature this month looks at two Russian Mars missions well along in development. The first, named Mars '94 (for its launch year), will deposit two landers and two penetrators in the region of Olympus Mons, according to current plans. The second, Mars '96, is more ambitious. We're talking here about an orbiter, plus a rover, plus a free-flying balloon. Wait, it gets better: The balloon soars during daytime; then as its gas bag cools after sunset, it drops to drag a "snake" (which may carry an instrument for soil-analysis) over the ground. After sunrise the balloon rises again to float over to a new region, and so on.

Incredibly, despite all of Russia's present economic and political turmoil, these two projects are going ahead rapidly. (Could we say as much for ourselves in similar circumstances?) The missions also have significant international contributions — including some from the United States, I'm glad to note — and that's a lesson that NASA has begun to take to heart in its programs.

There's another significant aspect to the Russian Mars missions: They show vision. They were cooked up by scientists and engineers who dreamt big. When it comes to space, politicians and bureaucrats always talk in terms of getting return for the money, and they do have a point. But the most important part of space exploration isn't necessarily firing boxcars into low Earth orbit. I think the point of a space program — maybe all of astronomy — is to take us *out* of our ruts, not make them more comfortable.

One concern lingers. For politicians, scientific exploration alone may not be reason enough to have a space program. Would Apollo have happened without the Cold War rivalries to drive it? I really wonder. And I worry that such considerations may prove far more important than any of us care to admit.

In any case, as you read this, Mars Observer, a spacecraft from the United States, is settling into Martian orbit and will soon start to work. Meanwhile, in Russia and elsewhere in Europe, engineers are cutting metal, shaping glass, and wiring circuits for mankind's *next* steps on Mars.

Sincerely,

Robert Burnham

Robert Burnham
Editor

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Letters

The Next 20 Years of Astronomy

I greatly enjoyed the article "What's Next for Astronomy" (August 1993). We will continue to make great strides in our understanding of the solar system through both space flights and Earth-based observations.

Great leaps in understanding will follow technological innovations. In the infrared part of the spectrum, we've achieved a gain of some 300 million in just 16 years. By developing new detectors and telescopes, we've doubled our sensitivity an average of once every 6.8 months.

Other technological advances such as optical interferometers coupled with giant adaptive optics telescopes will yield compositional maps of Pluto and its satellite, hundreds of asteroids, and most of the planetary satellites, all done from Earth.

Equally important are the theoretical advances that will come from advanced computation and visualization in planetary science. The development of interactive modeling with huge data sets (such as the Magellan radar imagery of Venus) will enable us to, for example, make computer movies at high resolution of the geological history of Venus. We will "observe" the impacts of asteroids and comets, crustal fracturing, the eruption of volcanos, and the other phenomena that have shaped the planet.

And best of all, we will generate a movie showing the origin and early evolution of the solar system and all it contains, complete with replay, fast-forward, stop-frame, and zoom. And it will all be genuine, based on real physics, theory, and observations. — *Dale P. Cruikshank, NASA Ames Research Center, Moffett Field, California*

We are beginning to see a turn right now. Amateurs are rediscovering the clarity and detail of images produced by long-focal-length refractors. Whereas 10 years ago the refractor was all but dead, it is now thriving once again. This trend will continue over the coming twenty years.

Advances in eyepiece design and accessories for observers and astrophotographers will develop at an ever-increasing pace. Remember when it took a 45-minute exposure to record the faint wisps of the Orion Nebula? In the future amateurs will record a snapshot of the same detail with a videodisk system, pop it into the computer inside the house, and have an observatory-quality image in minutes. — *Phil Harrington, Smithtown, New York*

[continued on page 12]

How Many Objects Can You Observe In One Night?

With The New C8+ Computerized Telescope, It's Entirely Up To You!

☑NGC 2403

☑M 83

☑M 97

☑NGC 253

☑M 8

Imagine observing hundreds of objects in one night. With the new C8+ computerized telescope you don't have to imagine. This revolutionary new telescope comes complete with a factory installed Advanced Astro Master that contains a data base of **over 8,000 objects.** Included are the New General Catalog, the Messier Catalog, 241 interesting double stars, all the major planets, and a 25 object user definable catalog. Once aligned, the C8+ computerized telescope will guide you to any of these objects in the order you want and at the rate that's just right for you. The 16-character LED readout displays a scrolling description of each object and cross references *Sky Atlas 2000.0* or *Uranometria.* To see the new C8+ computerized telescope, visit your local Celestron dealer or contact Celestron for a free product brochure.

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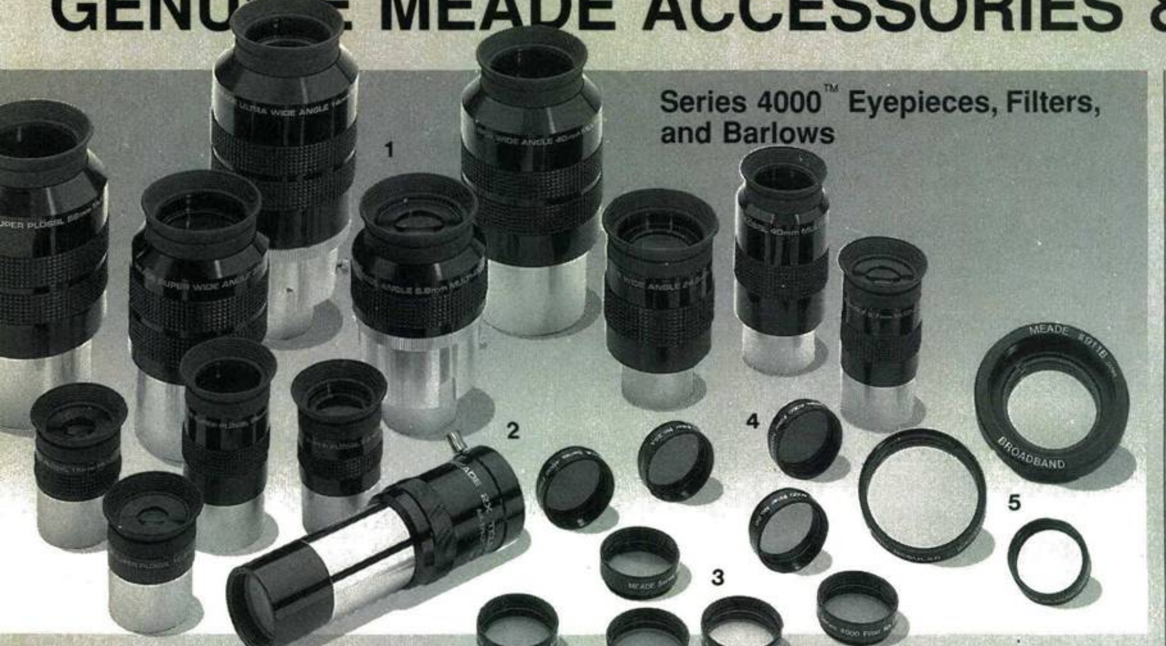

1 The World's finest telescope eyepieces now include rubber grips and soft rubber eyeguards for an even better observing experience! All eyeguards fold down for eyeglass wearers—a feature not available on competing brands. Best of all, **Meade Series 4000's are guaranteed to deliver more field, more contrast, and more image sharpness than any other brand at any price, or your money back.*** For splitting the closest doubles, revealing tenuous, faint nebulosity in deep-space, or studying hairline lunar and planetary detail, Meade multi-coated Series 4000's are the oculars that serious observers insist upon. ***"Clearly the best."***

Super Plössls (5-elements; 1.25"; 52°):
6.4; 9.7; 12.4; 15; 20; 26mm ea **$87.95** (3.29)
32mm(52°); **40mm**(44°); each **109.95** (3.79)
56mm (52°, 2") **229.95** (4.18)

Super Wide Angles (6-elements; 1.25"; 67°):
13.8mm: 139.95 (3.29) **18mm: 149.95** (3.29)
24.5mm: 169.95 (3.79) **32mm**(2")**: 239.95** (4.18)
40mm(2"): **299.95** (4.18)

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8.8mm(1.25"/2"): **229.95** (4.18)
14mm(1.25"/2"): **269.95** (4.18)

*at participating dealers; see catalog for details.

2 **#140: Series 4000 2x Apochromatic Barlow Lens** (1.25")--The original Meade 3-element, air-spaced, multi-coated design. Absolutely unmatched in image resolution and color correction. 28mm dia. lens (26mm clear aperture). **$79.95** (3.29)

3 **Series 4000 Photo-Visual Color Filters** (1.25")—Made of purest crown optical glass, dyed in the mass. For increased contrast on the Moon and planets . Thread into virtually all 1.25" eyepieces sold today. Fully coated.

#8 Lt. Yellow; #11 Yellow-Green; #12 Yellow; #21 Orange; #23A Lt. Red; #25A Red; #38A Dark Blue; #47 Violet; #56 Lt. Green; #58 Green; #80A Blue; #82A Lt. Blue.
each **$12.95** (2.29)

Set #1—4 filters: #12 Yellow, #23A Lt.Red, #58 Green, #80A Blue **$49.95** (2.79)

Set #2—4 filters: #11 Yellow-Green, #25A Red, #47 Violet, #82A Lt. Blue **$49.95** (2.79)

Set #3—4 filters: #8 Lt. Yellow, #21 Orange, #38A Dark Blue, #56 Lt. Green **$49.95** (2.79)

Sets #1 & #2—8 filters **$89.95** (3.29)

Sets #1, #2, & #3—12 filters **$129.95** (3.48)

4 **Series 4000 Moon Filter** (1.25")—Excellent for 4" to 12" telescopes. Reduces Moon brightness by 87%. **$15.95** (2.49)

5 **Series 4000 Nebular Filters**—The very latest in multi-layer interference coating technology, Meade premium nebular filters are guaranteed to be the finest obtainable at any price. Use a Series 4000 Broadband filter to block most forms of light pollution, with minimal attenuation of desired wavelengths. Use a Narrowband filter in heavily light-polluted areas, or for extremely high contrast observing of faint nebulae.

BROADBAND FILTERS

#908B (1.25")—Threads into all Meade 1.25" eyepieces, and virtually all other brands. Full 26mm clear aperture. **$79.95** (2.49)

#910B—Threads into all Meade 2" eyepieces and most others; 44mm dia. **119.95** (2.79)

#911B--Threads on to the rear cell of Schmidt-Cassegrain telescopes. **99.95** (3.29)

NARROWBAND FILTERS

#908N (1.25")—Threads into virtually all 1.25" eyepieces; 26mm clear aperture. **89.95** (2.49)

#910N—Threads into all Meade 2" eyepieces and most others; 44mm dia. **129.95** (2.79)

#911N--Threads on to the rear cell of Schmidt-Cassegrain telescopes. **119.95** (3.29)

World's Most Advanced Illuminated Reticle Eyepiece

Series 4000 Plössl 9mm, with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. Internal batteries included. Multi-coated optics. Bullseye reticle. 1.25" **$129.95** (3.29)

Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator. **$109.95** (3.29)

MA 12mm Illuminated Reticle Eyepiece

Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle. Includes wireless red LED illuminator with internal batteries and variable brightness control. **$94.95** (3.29)

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#929: Permits use of wide-field 2" oculars. Threads on to rear cell of Meade and Celestron SCT's. Includes multi-coated precision optical flat made at the Meade factory; with 1.25" eyepiece adapter **$99.95** (3.29)

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Professional-quality adapters for rigid coupling of telescope-to-camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-Mount, available separately.

.965": $27.95 (2.79) **1.25": $29.95** (2.79)

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Machined sliding cell allows variable projection power in eyepiece-projection photography; permits precise selection of correct photo power in lunar and planetary photography; threaded for filters. Use with T-Mount for your camera. **$39.95** (2.79)

Tele-Extenders

TELE-EXTENDER

For Eyepiece-Projection photography with any Meade or Celestron SCT. Threads on to eyepiece-holder. Use with T-Mount for your camera.

Basic Tele-Extender: *(above)* Fixed projection power; use with eyepiece for lunar and planetary photos. **$29.95** (2.79)

Variable Tele-Extender: Sliding cell, with lock, permits wide range of projection magnifications with the same eyepiece. **$39.95** (2.79)

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For Prime Focus photography with any Meade or Celestron SCT. Use with T-Mount for your 35mm camera. **$26.95** (2.79)

2X Telenegative Barlow (1.25")

#122: Doubles eyepiece power with sharp, high-resolution, high-contrast imaging on telescopes of all types. 27mm dia. (26mm clear aperture). Excellent corrections for chromatic and spherical aberrations at all photo-visual wavelengths. Multi-coated. 1.25" **$47.95** (3.29)

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#127: Precision internal sliding lens assembly permits continuously variable power settings between 2x and 3x. Engraved scale indicates power in use. Yields bright, sharp, high-contrast images on telescopes of all types. Multi-coated; 1.25" **$59.95** (3.29)

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Fine 4-element oculars that yield excellent image quality with any telescope. Computer-optimized design provides wide, flat fields, highly corrected for spherical and chromatic aberrations. Parfocal, multi-coated, 1.25" barrels. Threaded for filters. **Focal Lengths: OR 4, 6, 9, 12.5, 25mm.**

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#637: 6 x 30mm-Fine, 7° wide-field finder; coated, achromatic lens; crosshair eyepiece. 2-ring bracket with alignment screws. Attaches to tube diameters 6" to 12" **$49.95** (3.29)

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#544: 8 x 50mm--Same as #545, but in Meade blue. **69.95** (4.28)

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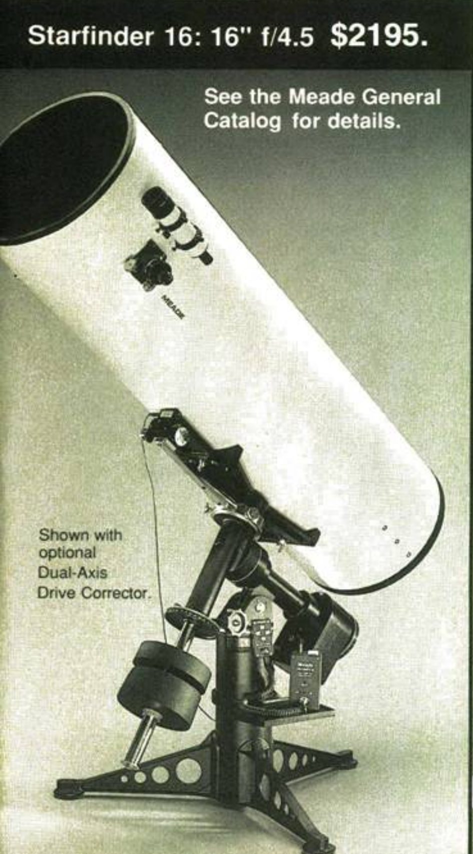

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A Meade Starfinder telescope opens up the skies to an extremely wide range of serious visual observing, to lunar and planetary photography, and even to limited deep-space photography. And every telescope is backed by the World's largest manufacturer of serious telescopes.

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■ **For further information call Meade Instruments at 714-756-2291 or contact one of these authorized mail-order dealers:**

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Specifications: 8″ Model 2080A—Complete with 8″ f/10 Schmidt-Cassegrain optical tube assembly; fork mount with setting circles, manual slow-motion controls and locks on both axes; 5.75″ worm gear motor drive system (115v./60Hz); eyepiece-holder (1.25″); diagonal prism; coated MA 25mm eyepiece (1.25″); 6 x 30mm viewfinder; equatorial wedge; variable-height all-metal field tripod. .... **$1099.**

Model 2080B—Identical to Model 2080A, but in addition with Super Multi-Coated optics. .... **$1149.**

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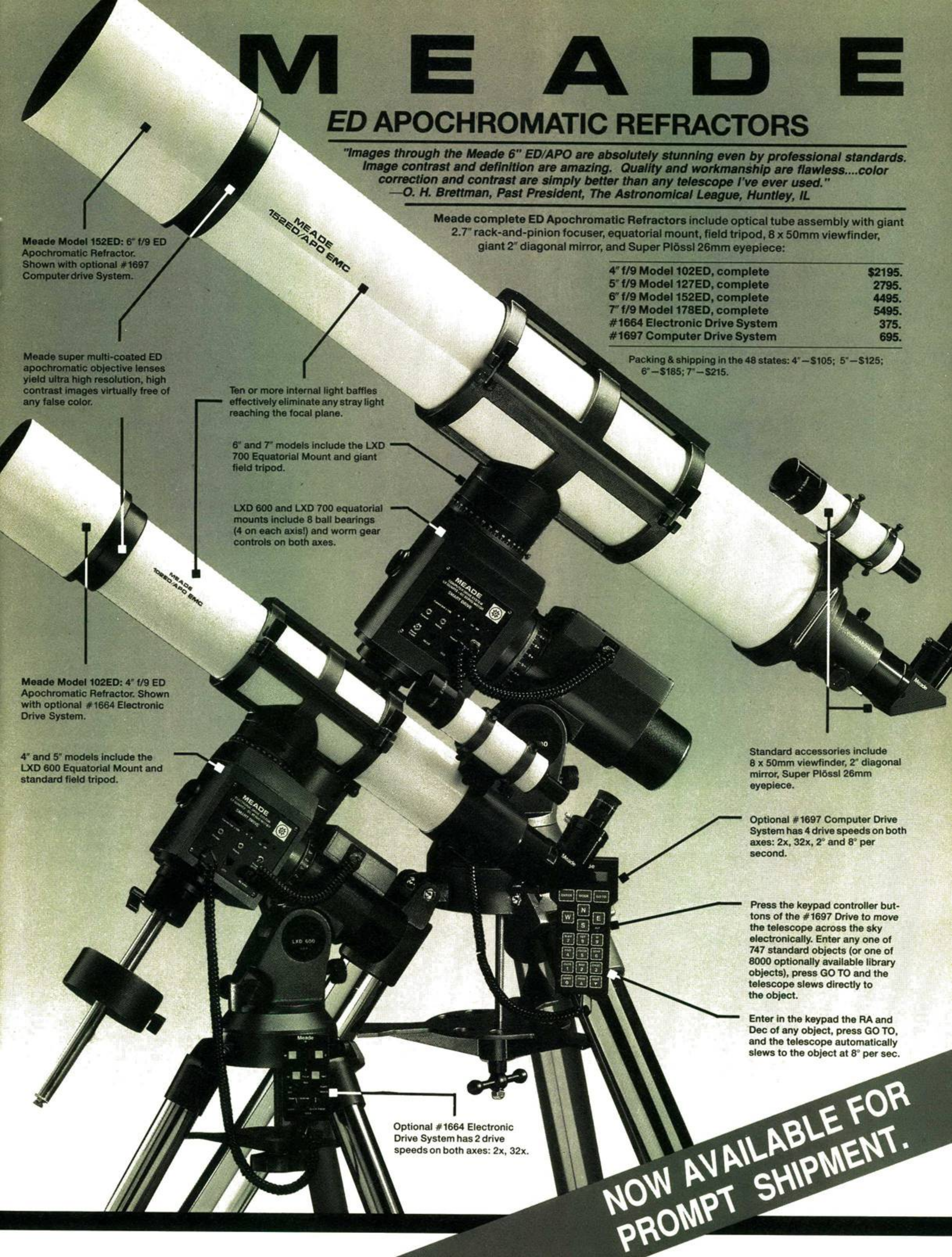
#1664 Electronic Drive System	**375.**
#1697 Computer Drive System	**695.**

Packing & shipping in the 48 states: 4"—$105; 5"—$125; 6"—$185; 7"—$215.



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Meade super multi-coated ED apochromatic objective lenses yield ultra high resolution, high contrast images virtually free of any false color.

Ten or more internal light baffles effectively eliminate any stray light reaching the focal plane.

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LXD 600 and LXD 700 equatorial mounts include 8 ball bearings (4 on each axis!) and worm gear controls on both axes.

Meade Model 102ED: 4" f/9 ED Apochromatic Refractor. Shown with optional #1664 Electronic Drive System.

4" and 5" models include the LXD 600 Equatorial Mount and standard field tripod.

Standard accessories include 8 x 50mm viewfinder, 2" diagonal mirror, Super Plössl 26mm eyepiece.

Optional #1697 Computer Drive System has 4 drive speeds on both axes: 2x, 32x, 2° and 8° per second.

Press the keypad controller buttons of the #1697 Drive to move the telescope across the sky electronically. Enter any one of 747 standard objects (or one of 8000 optionally available library objects), press GO TO and the telescope slews directly to the object.

Enter in the keypad the RA and Dec of any object, press GO TO, and the telescope automatically slews to the object at 8° per sec.

Optional #1664 Electronic Drive System has 2 drive speeds on both axes: 2x, 32x.

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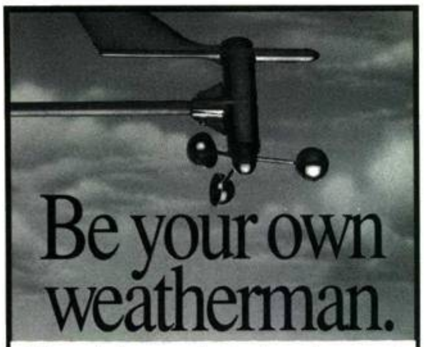

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Hey, Where is Everybody?

Recent research shows that planetary systems are likely prolific in our Galaxy ("Hubble Discovers Protoplanetary Disks in the Orion Nebula," April 1993). And water, amino acids, and other raw materials of life may have been brought to Earth by collisions with comets, asteroids, and other space dust and debris ("The Cosmic Origins of Life on Earth," November 1992). If Earth was bombarded from space with organics, the same process might have taken place in many planetary systems in the Milky Way and in many other galaxies.

Nature has developed a diversity of life forms in practically every imaginable environment on Earth. Why should life not develop elsewhere in the universe, in many environments different from that of Earth? If one understands the size and contents of the Galaxy and the nature of galaxies in the universe, the notion that life exists only on Earth is preposterous and illogical. — *Richard E. Danner, Northfield, Vermont*

The Big Switch

One of Mr. Burnham's recent editorials asked for ideas on CCD imaging. I have always been a visual observer but recently have found myself involved with CCD imaging, the first type of astrophotography, or astro-imaging, I've ever done.

Recent CCD images of the planets by Don Parker are astonishing. While I do not hope to duplicate Dr. Parker's success, his images have inspired me to try to capture high-resolution planetary detail. Until now such features were visible only to visual observers. They could not be accurately recorded on conventional film. CCDs allow imagers to record these details.

In addition, CCDs allow backyard astronomers to capture deep-sky objects even from relatively light-polluted sites. This is too much — perfect lunar and planetary and deep-sky images from a less-than-perfect location. I decided to jump into the fray even if it meant — argh! — learning how to use a computer. Last autumn I ordered an ST-6 camera for my 9-inch f/15 refractor, and I have been happily experimenting ever since. Your articles have not exaggerated the message — CCDs have ushered in a *revolution*. — *Jim Phillips, Charleston, South Carolina*

Mars: Surf's Up!

I enjoyed the story about the sands of Mars (June 1993), including the possibility of finding water in them. But how did the water get there? The present axial tilt of Mars is 25° and nothing melts from the ice caps. Was the tilt greater once? — *E. L. Lee, Dallas, Texas*

Mars' axial tilt has swung erratically from 0° to 60° during the planet's history. But more important is having an atmosphere thick enough for liquid water to exist at the surface. Early Mars had a thick atmosphere and was probably both warm and wet. But scientists think it has been cold and dry for most of the last three billion years. However, one new theory proposes that lava flowing over beds of carbonate rocks may have released enough carbon dioxide to give Mars (temporarily) a fairly thick atmosphere again in the recent past.

Van Biesbroeck Award

Georges Van Biesbroeck was born in Belgium in 1880 and emigrated to the United States during World War I. He became one of the great astronomers of his era, carefully measuring the positions of comets, asteroids, and double stars. He was largely responsible for the founding of McDonald Observatory in Texas.

After Van Biesbroeck's death in 1974, his family and friends raised funds to publish the professor's final research. The monies left from this have since been used to issue an annual Van Biesbroeck Award, given to astronomers such as Janet Mattei of the AAVSO, whose significant, unselfish contributions to astronomy have made a difference in the field.

The Van Biesbroeck Award Committee would like to continue this tradition. Contributions are tax deductible. Please send contributions to Marcia Rieke, Van Biesbroeck Award, Inc., 5801 North Paseo Ventoso, Tucson, AZ 85715. Thank you. — *Tim Hunter, Tucson, Arizona*

Correction

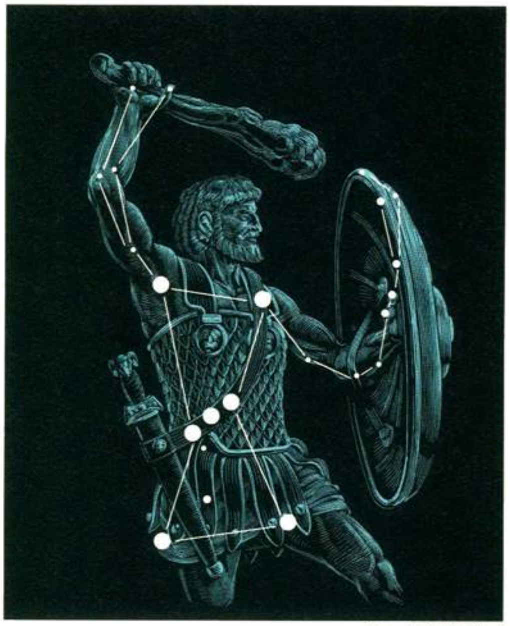
The photograph on page 21 of the February issue was taken by Annika Johansson.

The photograph at top left on page 77 of the June issue was taken by Jack Newton. ☐

ASTRONOMY welcomes suggestions and additional information about articles and astronomy in general. Send your letters to ASTRONOMY Letters, P.O. Box 1612, Waukesha, WI 53187. Letters may be edited for length and clarity.

WHY LEARN STAR NAMES?

by Thomas Henry



Orion by Keith Ward

Betelgeuse, Vega, and Sirius. Every backyard astronomer knows these names because the stars they refer to are among the brightest in the sky. But could you find Seginus, Muliphen, and Rutilicus? You probably could if I told you these stars are also called Gamma Bootis, Gamma Canis Majoris, and Beta Herculis. An acquaintance with the Bayer designations (using a constellation name and Greek letters for the stars roughly in order of brightness) allows you to sensibly navigate around the starry sky. So is it really important to know stars' proper names?

Many astronomy books would have you believe that only a dozen or so stars have proper names worth remembering, suggesting that most star names are but historical curiosities. I disagree! I can think of three good reasons for learning about 200 star names.

First, a star name, or its meaning, often tells you about its position in the sky, describes its connection with other stars, or portrays its appearance to ancient astronomers. The best known example is Polaris. This name for the star is a shortened version of its full Latin name Stella Polaris, which means "the star of the pole." It got this name because it is the closest bright star to the north celestial pole. Shaula (Lambda Scorpii) is the Sting, referring to this star's position at the tip of Scorpius the Scorpion's tail. Dschubba (Delta Scorpii) is "the forehead" of the Scorpion. Betelgeuse (Alpha Orionis) means "the armpit of the Central One," describing its position in Orion the Hunter's right shoulder.

Murzim — the name of Beta Canis Majoris — means "the announcer," or more properly "the roarer." Murzim lies west of Sirius, so it rises first and announces the rising of Sirius. Because it is the brightest star in the sky, Sirius became an obvious marker for important events in the daily and religious lives of many ancient peoples. It was essential to have a predictor proclaiming the imminent arrival of this star.

Incidentally, Sirius means "sparkling" or "scorching," the latter undoubtedly referring to its association with the hottest or "dog" (from Canis Major the Great Dog) days of summer. Alnilam, the central star of Orion's Belt, means "string of pearls," which refers to the belt's appearance.

Second, star names can serve as mnemonics or memory hooks to keep you from getting lost as you steer your binoculars or telescope through the sky. Suppose you want to find the globular star cluster called M10 (the tenth object listed in Charles Messier's catalog) in Ophiuchus the Serpent Bearer. You can try to memorize a star hopping path from various stars, all with Greek and number designations. Or you can simply trace two lines. Imagine Ras Alhague (Alpha Ophiuchi, "the head of the Serpent Bearer") at the top of the constellation. Draw one line up from Han (Zeta Ophiuchi, which was named after a feudal state in China) near the left knee of the Serpent Bearer toward Ras Alhague and one to the left (east) from Marfik (Lambda Ophiuchi, "the elbow" of the Serpent Bearer). The two lines intersect at M10. "Up from Han and left from Marfik" is easier to remember than the number of degrees or telescope field diameters from Delta Ophiuchi.

Third, if you give a slide show or host a star party, you'll find people are fascinated by star names and their meanings. This is a great excuse for pointing out a few of these stars to the public. You

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could draw your audience's attention to Libra the Scales, slightly to the west and north of Scorpius.

Although this region has few bright stars, the two brightest stars have almost magical names: Zubenelgenubi and Zubeneschamali. What makes these stars interesting to me is that their names mean "Southern Claw" and "Northern Claw." Ancient Greeks saw these stars as the claws of the Scorpion. The Romans established the constellation Libra around the first century B.C. But if you point out the version of Scorpius complete with claws, your audience will have a great way to find the nondescript constellation Libra.

If you agree with me that learning star names is important, then we need to discuss how to learn the collection of Greek, Roman, and Arabic names, including such tongue twisters as Alkaffaljidmah and Alkulurops. The task needn't be Herculean. After all, think about all the kids you went to elementary school with, add in your high school class, college friends, coworkers, and the names of baseball players, politicians, movie stars, and other people whose names you remember. The list of names that come easily to the tip of your tongue can run into the thousands.

You didn't learn all of these names overnight, so don't expect to learn all the star names at once. You need a plan, taking a day or two to learn the star names in a constellation. In several months, you should have learned two hundred names — and the constellations if you haven't learned them already.

A good place to start your exploration of star names and their meanings is Richard Hinckley Allen's *Star Names and Their Meanings* (Dover Publications, 1963). And a few tricks can help you learn the names. Try sketching the constellation pattern. Associating the names and spatial relationships between the stars can help prime your memory. Label the stars on your sketch with their proper names and practice pronouncing the names out loud. Vocalizing helps some people fix the names in their mind. Others find writing the name down several times helps them remember it.

Some people find associating a name with a silly — in this case, the more outrageous the better — mental image helps. For example, you might think of a huge pitcher of Kool Aid spilling over the Big Dipper to remember the name of the last star in the Big Dipper's handle, Alkaid. Dubhe, the brightest star in Ursa Major the Great Bear, is in the bowl of

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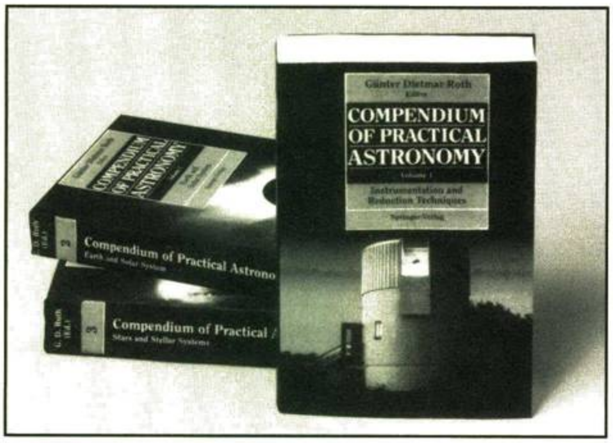
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the Dipper. Think of the Bear as a great singing star, crooning "doo be, doo be, doo." Any mental images you come up with will work, but the more outlandish ones will stick in your mind longer.

One important step in learning the names is to review frequently. Of course, you could do this in an easy chair. But a better place is outside under the stars. Learning star names with a friend can help, because you can teach each other new names.

A stumbling point for many neophytes learning star names— and experienced astronomers, too — is pronouncing these foreign names. Hearing the name pronounced at a star party or an astronomy club meeting can help, but some stars have several pronunciations. Some say "VAY-gah" and others "VEE-gah" for Alpha Lyrae. You'll hear Betelgeuse as "BEE-tel-joos" and "BAY-tel-juz" and Ras Algethi as "ROSS all-JEE-thee," "ROSS el-JE-ti," and "RAS all GE-thee." Part of the differences in pronunciation arises from the fact that some names come from long-dead dialects. Some of the differences — and spelling differences you might see — come from transcriptions of names into English. For example, Betelgeuse comes from the Arabic Ibt al Jauzah, which degenerated into Bed Elgeuze, Beteigeuze, Betelgeuze, and Betelgeuse. So what's a beginner to do? Remain flexible, adjust your pronunciations to match those you hear from people you expect know more than you, and in case of a tie, imagine that your version is probably as close to correct as anyone else's.

To complicate learning star names, some books incorrectly label star names. Zubenelakrab is sometimes given as the name of Eta Librae (one book has it incorrectly as Delta Librae) while others list this name for Gamma Scorpii. Also some names were used for more than one star. Murzim has graced Beta Canis Majoris and Gamma Orionis (more commonly known as Bellatrix, the "Amazon Star").

As you learn these star names, I guarantee that the sky will take on a new liveliness. No longer will stars be Alpha Cancri or Alpha Pegasi. You'll now know them as Acubens, "the claws" of the Crab, and as Markab, "the saddle." Suddenly the stars will be friends that you can name on sight. You'll find yourself passing on what you've learned at star parties or perhaps in a talk at a school. Perhaps your recounting of the marvelous names and their meanings will spark in someone a life-long interest in astronomy. □

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"We expected to be studying a cloud with a smooth structure similar to that of a lump of jello. Instead, the cloud is composed of a bunch of clumps, some of which are very small indeed." That's how Dan Clemens of Boston University describes his observations of one of the smallest, least massive clouds of hydrogen ever studied. Along with Robert Dickman of the National Science Foundation and David Ciardi of the University of Wyoming, Clemens is probing a tiny nebula called LBN 11, the eleventh entry in Beverly Lynds' bright nebula catalog.

At the center of the nebula the team thinks it has found two orbiting clumps of matter that may be stars in the process of forming. The nebula has a total mass equivalent to only two of our Suns. The two central condensations deep in the nebula each contain less than 15 percent of the mass of the Sun and orbit one-tenth of a light-year apart, taking one million years to dance around each other. The gas clumps may continue to collect more gas, grow larger, and drag against the neighboring parts of the nebula.

If this happens, the clumps will drift closer together, shrink, heat up, and turn into a pair of protostars. Continuing the process would lead to the formation of a binary star system — something common in the universe. "Binary protostars are currently being discovered in other gas clouds," explains Clemens. "But inside LBN 11 we have found evidence of what the earliest stages of binary star formation may look like."

NO MORE PLANET X

Astronomers have long invoked the existence of a tenth planet, "Planet X," to account for the drifts of Uranus and Neptune from their predicted positions. Some even have blamed Planet X for causing periodic comet showers, releasing Pluto from Neptune's gravitational grip, and reversing Triton's orbit around Neptune.

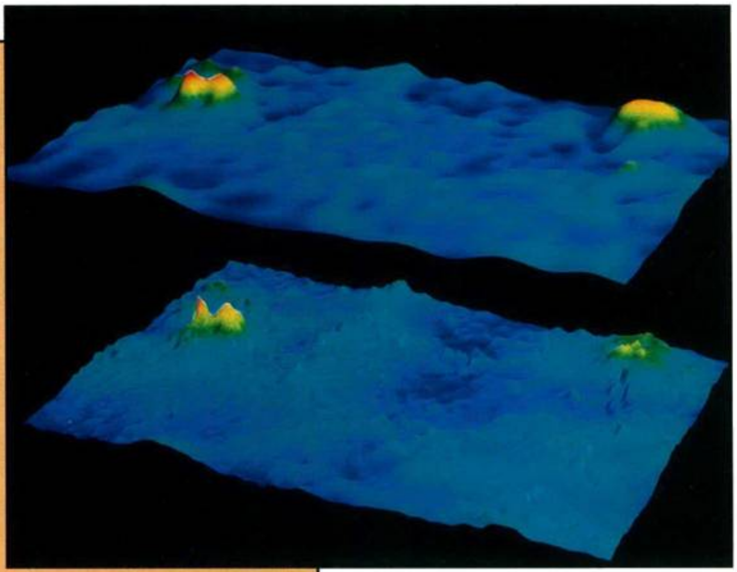
But according to a recent study by Myles Standish of the Jet Propulsion Laboratory, the need for Planet X has all but vanished. He showed that the irregularities in the orbits of Uranus and Neptune result from the slightly incorrect values for the masses of the giant planets used in previous studies. When Standish used more accurate values determined from

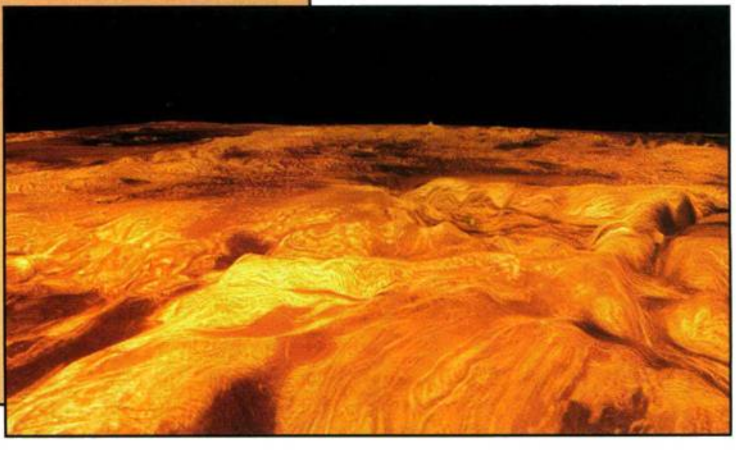
MAGELLAN VIEWS VENUS

In late May, the Magellan spacecraft completed its fourth mapping cycle of Venus, this one dedicated to analyzing the planet's gravity. Unlike on Earth, the strength of gravity on Venus matches the topography of the planet (right). In other words, high spots exert more gravity (light blue) and low spots exert less (dark blue). On Earth lighter materials rise, so mountainous regions are less dense and exert less gravity. Planetary scientists think the difference occurs because fluid motions in the mantle play a more important role in forming features on Venus than on Earth.

The image shows an area 12,700 kilometers by 8,450 kilometers that extends from 180° east to 300° east longitude and from 40° north to 40° south latitude. The highest spots, Beta Regio and Atla Regio, exert the strongest gravity. These areas are home to large volcanos where hot mantle material apparently wells up, similar to hot spots on Earth like Hawaii.

The computer-generated perspective view of the highland Ovda Regio (right, below) shows Magellan radar data superimposed on topography. Ovda Regio covers an area 6,300 km by 2,100 km and rises more than 3 km above the surrounding plains (the vertical scale is exaggerated here 22.5 times to better show detail). In several places you can see where lava flows (which are smooth and thus dark in the radar images) flooded the ridges, indicating that the ridges formed before the lava flowed.





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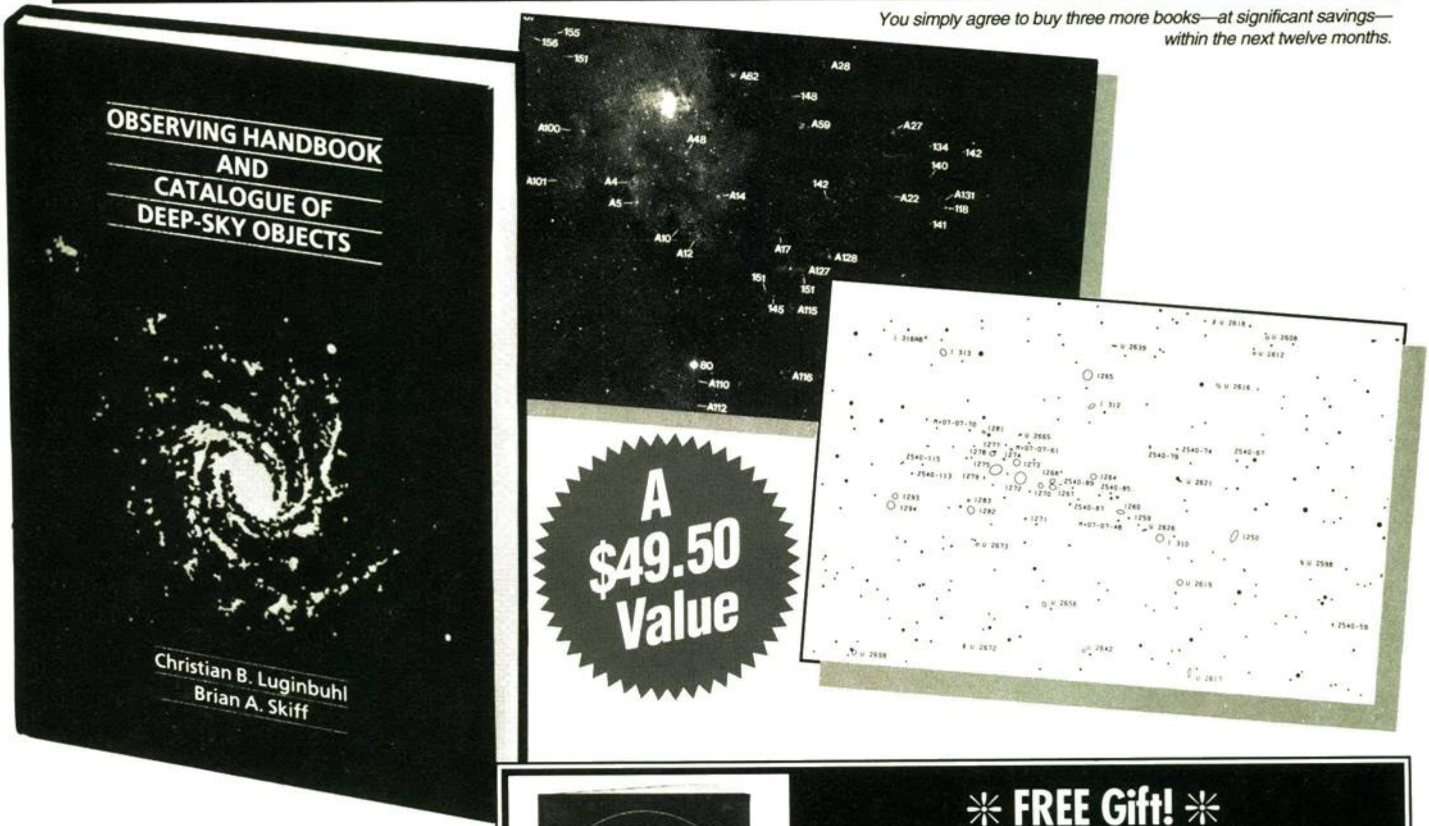

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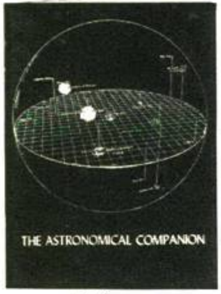

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Astronomy 10/93

data obtained by the Voyager spacecraft, the irregularities disappeared.

The quest for Planet X began with the discovery of Neptune in 1846. Discrepancies between the computed and observed orbits of Uranus guided astronomers to the new planet. But Neptune's discovery didn't explain the discrepancies entirely, leading some astronomers to look for another planet on the outskirts of the solar system. In 1930 Clyde Tombaugh discovered Pluto but it, with a mass 1/500 that of Earth's, is too small to pull Uranus and Neptune off course. So the search began for a tenth planet. Standish's findings now suggest that Planet X hunters may return empty-handed. — *Ray Jayawardhana*

AN IDENTITY CRISIS FOR M81'S SUPERNOVA

Supernova 1993J was the tenth supernova detected so far this year and the brightest seen in the Northern Hemisphere since 1937. Early observations showed that the supernova, which occurred in the spiral galaxy M81, was a type II, because lines due to hydrogen dominated its spectrum. But a month after the star's outburst, Alex Filippenko and Tom Matheson of the University of California in Berkeley found helium lines in the supernova's spectrum, indicating that it had transformed into a type Ib.

Whereas other type I supernovae seem to occur when matter from a companion star rushes onto a white dwarf and causes an explosion, type Ib supernovae seem to arise from the sudden collapse and subsequent explosion of a massive star, just like type IIs. To explain the change in the spectrum of SN 1993J, astronomers suggest that it had only a

Space News

CUTTING THE COST OF FREEDOM

To the uninitiated, the new space station looks similar to the old Freedom Space Station. But to NASA, Congress, and the President, the new design represents an $18 billion saving in construction and operations costs over the 20-year lifetime of the orbiting station.

President Clinton selected the new space station design in June from a trio of options offered by NASA and independently assessed by a blue-ribbon panel chaired by Charles Vest, President of MIT. Option A, the one selected, builds up the space station from a single core lab module. Compared to the original Freedom plans, the new design incorporates fewer truss segments and uses more common modules and simplified power and environmental systems to cut costs. Rejected Option B made use of more existing Freedom components. Option C, a radical redesign, consisted of a large central module launched in one piece with a minimal capacity to expand by adding lab modules built by other countries.

Under the modular design President Clinton selected, the first shuttle to deliver station components into orbit will blast off in October 1997. By December 1997, after only three construction flights, the station will be ready for use as a giant power supply. Astronauts won't yet live on the station, but the shuttle with an existing Spacelab on board will dock with the station and use its solar arrays to power the shuttle/Spacelab combination for three-week missions.

One more shuttle flight will give the station what NASA calls "human tended capability." By spring 1998 the station will include its central U.S.-built core/lab module with experiment racks, a Canadian remote manipulator arm, an Italian logistics module, and additional docking ports. However, the shuttle will still remain docked while the station is in use.

By December 1999, an additional 8 shuttle flights will bring the station to its "international human tended" phase. The station will then contain the Japanese Experiment Module, the European Space Agency's Columbus module, and more solar arrays. Astronauts will carry out research during 20-day-long shuttle missions. Between shuttle flights, the station will be deserted.

Not until September 2000 does the station acquire "permanent human capability." Achieving this milestone requires four more shuttle flights to add a habitation module, airlock, and more solar power arrays. The shuttle will deliver crew to the station who remain on board after the shuttle leaves. Two Russian Soyuz spacecraft remain attached as lifeboats to get the crew back to Earth in the event of an emergency.

The Vest Committee estimates it will cost $25 billion to bring the space station to this permanent status, $9 billion of which has already been spent over the years in developing Freedom. By comparison, the committee estimates that the real cost of bringing the original Freedom design to permanent status would have been $8 to $9 billion more and cost another $1 billion a year for ten years to operate.

While the changes in the physical design account for some of the savings, most of the cuts will come from streamlining NASA's management. In his statement to the press, President Clinton said, "We are going to redesign NASA as we redesign the space station." A senior administration official suggests that "NASA as currently structured cannot build this space station or any other, and a 30 percent reduction in federal and contract employees is required to be able to produce any space station. Right now, the management structure is labyrinthine. Everybody is in charge and no one is accountable."

Although the new design saves money in the long run, NASA's approved 1994 budget now calls for $2.1 billion earmarked for the station, $300 million more than originally asked for. The $300 million comes out of a fund for developing new technology at NASA which includes NASA's low-cost Discovery planet probes (see "Cheap Shots," August 1993). Fortunately, funding for the first Discovery mission was not affected, although NASA has not yet decided if this will be the MESUR Mars lander or the NEAR asteroid probe. The major mission to Saturn, Cassini, also received full funding in the 1994 budget. However, NASA cut funds to Missions Operations and Data Analysis, a move which may jeopardize the rapid processing of data from existing craft such as Galileo at Jupiter and the Mars Observer orbiter.

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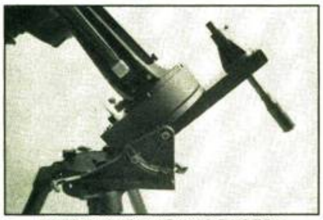
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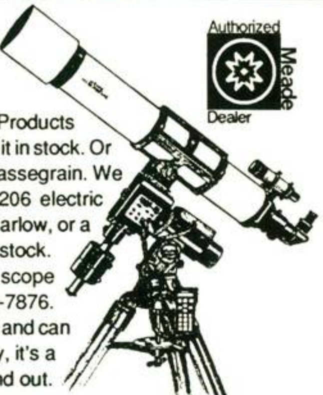

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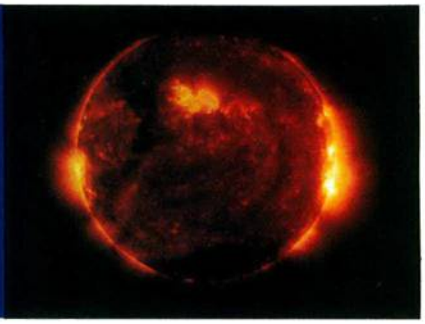
thin layer of hydrogen surrounding the star when it exploded. The star probably had a thick hydrogen layer originally but a companion star captured most of the hydrogen. The remaining hydrogen emitted the Type II spectrum immediately after the explosion but the gas thinned as it rushed outward, causing the hydrogen lines to weaken. Now astronomers are viewing through the thin hydrogen gas to hotter, lower-lying gas and seeing lines of helium in the spectrum. Later, as the gas thins even more, lines of oxygen and calcium should appear in the spectrum.

From the brightness of SN 1993J and its spectrum, astronomers have determined that the stars' mass before the explosion was 10 to 20 times that of the Sun's. Most likely the star has collapsed into a neutron star, although observers will have to wait until the shell around the star thins some more to confirm this.

THE BEST LOOK AT STARS YET

Astronomers are making observations of stars with unprecedented resolution, using the Mark III optical interferometer. The instrument, located on Mount Wilson outside Pasadena, California, uses two small telescopes to mimic the resolving ability of 3- to 31-meter-diameter scopes. With a resolution as small as two-thousandths of an arcsecond (250 times better than normal ground-based observations), astronomers have looked at hydrogen disks around three hot stars, observed 20 close binary stars, and measured the diameters of 10 cool giant and supergiant stars.

The research team, consisting of Richard Simon and David Mozurkewich of the Naval Research Lab and J. Thomas Armstrong, David Buscher, Christian Hummel, and Andreas Quirrenbach of the Universities Space Research Association, also observed how Arcturus changes brightness across its disk. They found the limb, or edge, darkened by 85 percent compared to the center. This confirms theoretical models of how the gaseous atmosphere of Arcturus emits light.



LOOPS AND ARCHES RISE ABOVE magnetic regions on the Sun's surface and help heat the corona to over a million degrees. This image taken in April 1993 with an X-ray telescope aboard a Black Brant rocket also shows dozens of bright points that lie above small, intense magnetic fields and large, dark holes that mark cooler regions in the corona.

IBM Researcxh and Smithsonian Astrophysical Observatory

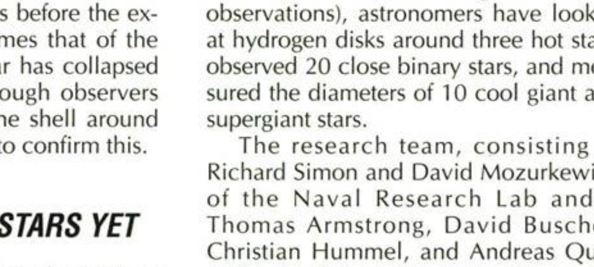
These remarkable observations are just the first expected from the Mark III interferometer and demonstrate its extraordinary resolution. Its ability to split close binaries and measure stellar diameters and limb darkening provides a unique research tool for probing stellar properties.

24-KARAT SUPERNOVA

Where do heavy elements such as gold, platinum, and uranium come from? Stan Woosley and Robert Hoffman of the University of California at Santa Cruz and their colleagues think they have the answer — supernovae. They knew that the big bang created only hydrogen, helium, and a few light elements such as lithium and boron and that all other elements must have formed in the interiors of stars. Simple fusion of atoms can build elements as heavy as iron, while the slow capture of neutrons by atoms in a star's core can build some elements heavier than iron.

But to build gold and uranium from lighter elements requires the rapid capture of neutrons, the so-called r-process. Astronomers have been uncertain about where the r-process occurs, thinking it might happen in stellar cores or during the collision between a neutron star and a black hole. The Woosley and Hoffman team found that supernovae can assemble heavy elements from light nuclei and don't require heavy "seed" elements like iron to operate. Key players in their scenario are the neutrinos created by the collapse of the original supergiant star into a neutron star. They heat the gas just above the neutron star to billions of degrees, creating the conditions necessary to build as heavy as nuclei silver during the first few seconds after the star exploded. From these elements rapid neutron capture produces heavier elements such as gold, platinum, and uranium.

GALILEO MAPS VENUS' TOPOGRAPHY



JPL/NASA

The Near Infrared Mapping Spectrometer (NIMS) aboard the Galileo spacecraft imaged Venus when the craft flew past the planet in February 1990 on its way to Jupiter (see the April 1991 issue).

Recently, a team of project scientists led by the Jet Propulsion Laboratory's Robert Carlson processed the NIMS data to reveal surface details on Venus seen through the planet's visually opaque atmosphere. The instrument "saw" cool spots that coincide with the planet's known mountains (as mapped by the Pioneer Venus and Magellan space probes); these reflect the cooler temperatures of the ground and the atmosphere over the high elevations.

The result is significant because it shows that on future missions scientists can study temperature variations in the atmosphere of Venus using this kind of instrument. It also holds out the hope of spotting fresh volcanic eruptions, should they occur.

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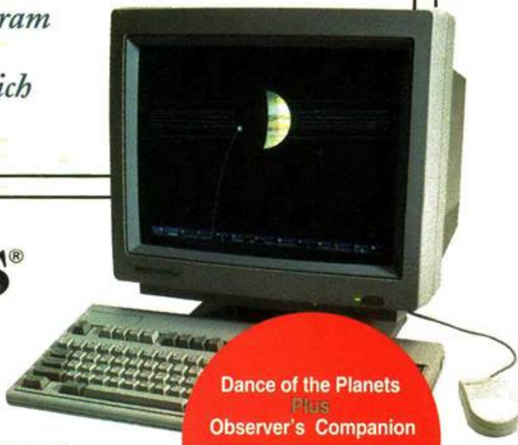
Below - Captured Comet Shoemaker-Levy (1993e) impacting Jupiter, July 1994.



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Amateur News

PARTY WITH THE STARS

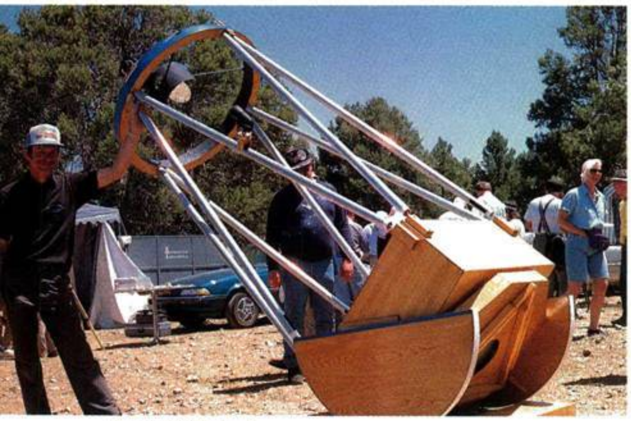
Ben Funk

TENTS AND TELESCOPES scatter across the Prude Ranch at the 1993 Texas Star Party, where 800 astronomers enjoyed the dark skies.

Two major spring star parties attracted hundreds of amateur astronomers to Texas and California. From May 16-23, 1993, about 800 skywatchers descended on Fort Davis, Texas, for the Texas Star Party (TSP). Held at the Prude Ranch about ten miles from McDonald Observatory, the annual event featured dark-sky observing, fields full of large and innovative telescopes, and daytime talks.

This year's weather provided several good nights of dark, clear skies as well as two nights washed out by storms. Nevertheless, the battery of large reflectors had ample time to sweep the heavens in search of faint galaxies and nebulae. One 32-inch telescope and twelve 25-inch scopes dotted the observing fields — many observers brought 20-inch or 18-inch scopes.

The talks covered a wide range of current hot topics in backyard astronomy. Daytime talks given by amateurs concentrated on deep-sky observing: Scott Mitchell of Houston described how to sketch deep-sky targets, Bill Harris of Jasper, Alabama, showcased galaxy photos he has taken at the TSP, and Tom Mote of San Antonio explored deep-sky databases. Equipment for observing also took center stage as Emil Bonnano of Houston described his MegaStar computer program — fueled by an awesomely powerful database. San Antonio's Robert Reeves provided a decidedly different presentation with his "star people," which analyzed the career histories of well-known amateur astronomers.


Astronomy: Alan Dyer

A LIGHTWEIGHT GIANT is how Steve Overholt describes "Starship," his 30-inch reflector that fits into his hatchback car.

The hit evening presentations highlighted beautiful color imaging of deep-sky objects and planets. Tony and Daphne Hallas traveled from southern California to transport TSP attendees on a journey atop Mt. Pinos, a popular astrophotographer's hangout north of Los Angeles. The Hallas' superb color images of galaxies and nebulae illustrated their Disneyesque talk which used a space shuttle to explore the heavens. On the final night, Floridian Don Parker described his techniques for imaging planets using CCD cameras from his home observatory and also presented images of galaxies borrowed from friend Jack Newton.

Next year's TSP will take place from May 8-15, 1994, at the Prude Ranch in Fort Davis. The TSP staff will organize an expedition to leave the star party grounds on May 10 and travel north to the centerline for the annular eclipse of the Sun. For more information, contact Mike Dennis, P.O. Box 21221, Oklahoma City, OK 73156.

In the week following the TSP a number of star party fans made the trek from the Prude Ranch to California to attend the 25th annual Riverside Telescope Maker's Conference. From May 28-30, about 1,800 amateur astronomers converged on Big Bear Lake for a weekend filled with telescopes. At Riverside, telescope makers show off their homemade creations while commercial companies demonstrate their latest products.

One of the most ingenious telescopes on the field this year was Steve Overholt's 30-inch f/3.75 Dobsonian, a telescope so cleverly designed it can break down to fit into Overholt's Ford Festiva and weighs less than a Coulter Odyssey 17.5-inch scope. Stunning views of deep-sky objects were provided by Rich Livitski's 20-inch binocular telescope — yes, a pair of 20-inch reflectors together on the same Dobsonian mount. The award for the largest portable telescope at Riverside (and perhaps at any star party!) must go to the members of the Valley of the Moon Astronomical Society in Glen Ellen, California, and their 40-inch reflector. Needless to say, the lines were long for a peek through this monster telescope.

Although touring the dozens of telescopes on display and shopping for bargains is entertainment enough at Riverside, conference organizers Steve Edberg and company also provided a full program of speakers. Guest of honor Tom Johnson, founder of Celestron International, regaled the audience with stories from Celestron's early days 25 years ago when it began producing the first commercial Schmidt-Cassegrains. Their first ad for the Celestron 8 brought in orders for 20 instruments. To date, Johnson estimates Celestron has produced 300,000 telescopes.

A panel discussion on the future of homemade telescopes stirred up a lot of audience involvement. What type of amateur telescopes will we see at Riverside in the decades to come? Participants envisioned giant scopes with featherweight mirrors, arrays of telescopes feeding light to a common focus, scopes with adaptive optics, even an amateur space telescope orbiting overhead which conference participants could communicate with — in short, whatever technologies professional astronomers are now using will sooner or later become available to amateurs.

As it is each year, the 1994 Riverside Telescope Maker's Conference will be held over the Memorial Day weekend, May 27 to 29. □

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WANTED — Twenty-seven-year-old Chinese male seeks correspondence with others worldwide who are interested in astronomy, "Star Trek," science fiction and other sciences. Contact Jimmy Ting, 112 Panay Avenue, Quezon City, 1103, Philippines.

WANTED — Giant binoculars, preferably 80 mm, 100 mm, or larger. Must be in like-new condition. Also interested in purchasing 80 mm or larger spotting scopes. Contact Carl Dame, Box 90, Ashland, IL 62612.

WANTED — Twenty-seven-year-old female interested in philosophy, mythology, religious practices, NASA, astronomy, UFO phenomenon, and open-minded discussions on the existence of God seeks correspondence worldwide with others of all ages. Contact Francie Woodside, 4171 Windsor Castle Way, Decatur, CA 30034. ☐

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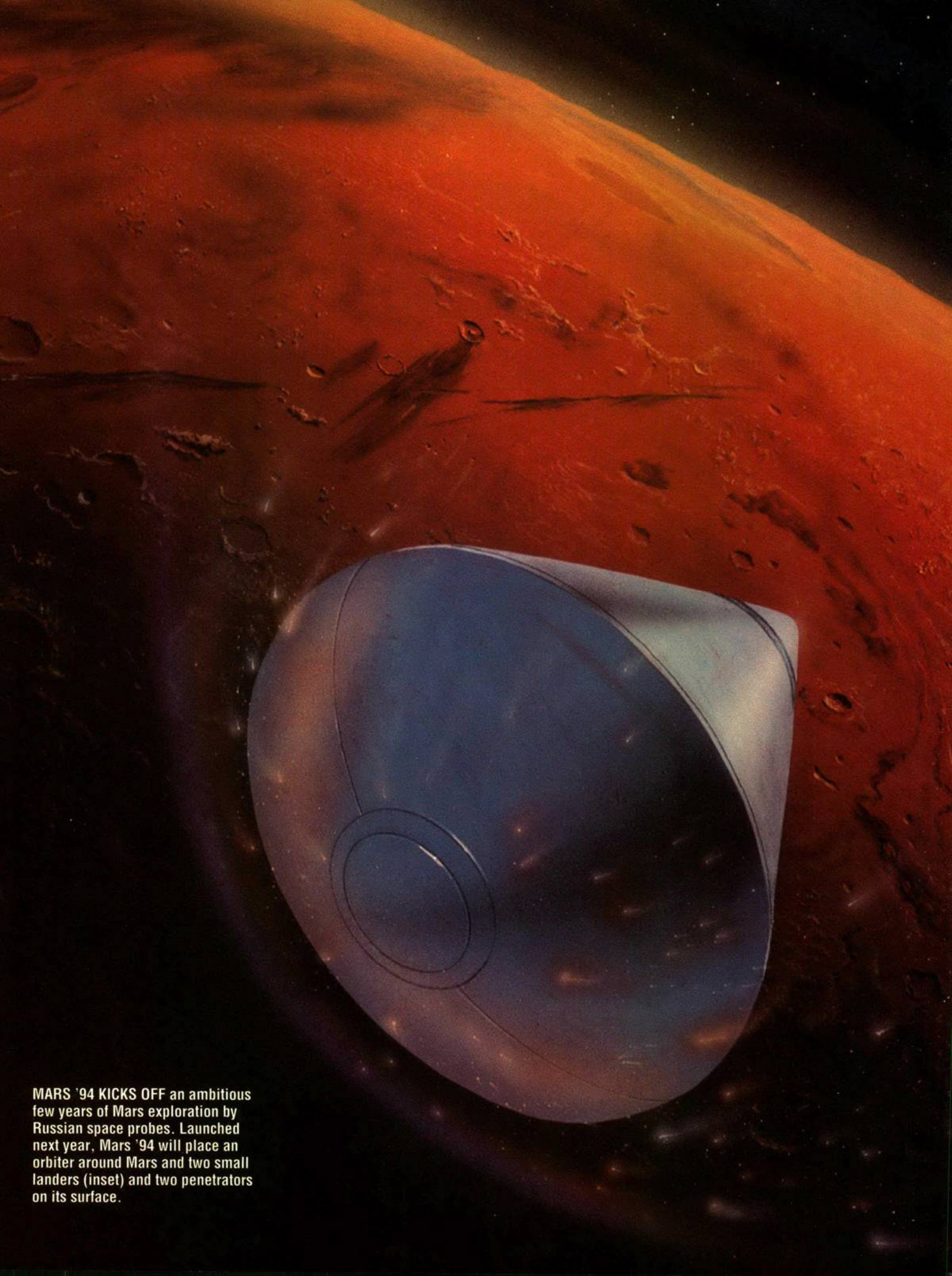
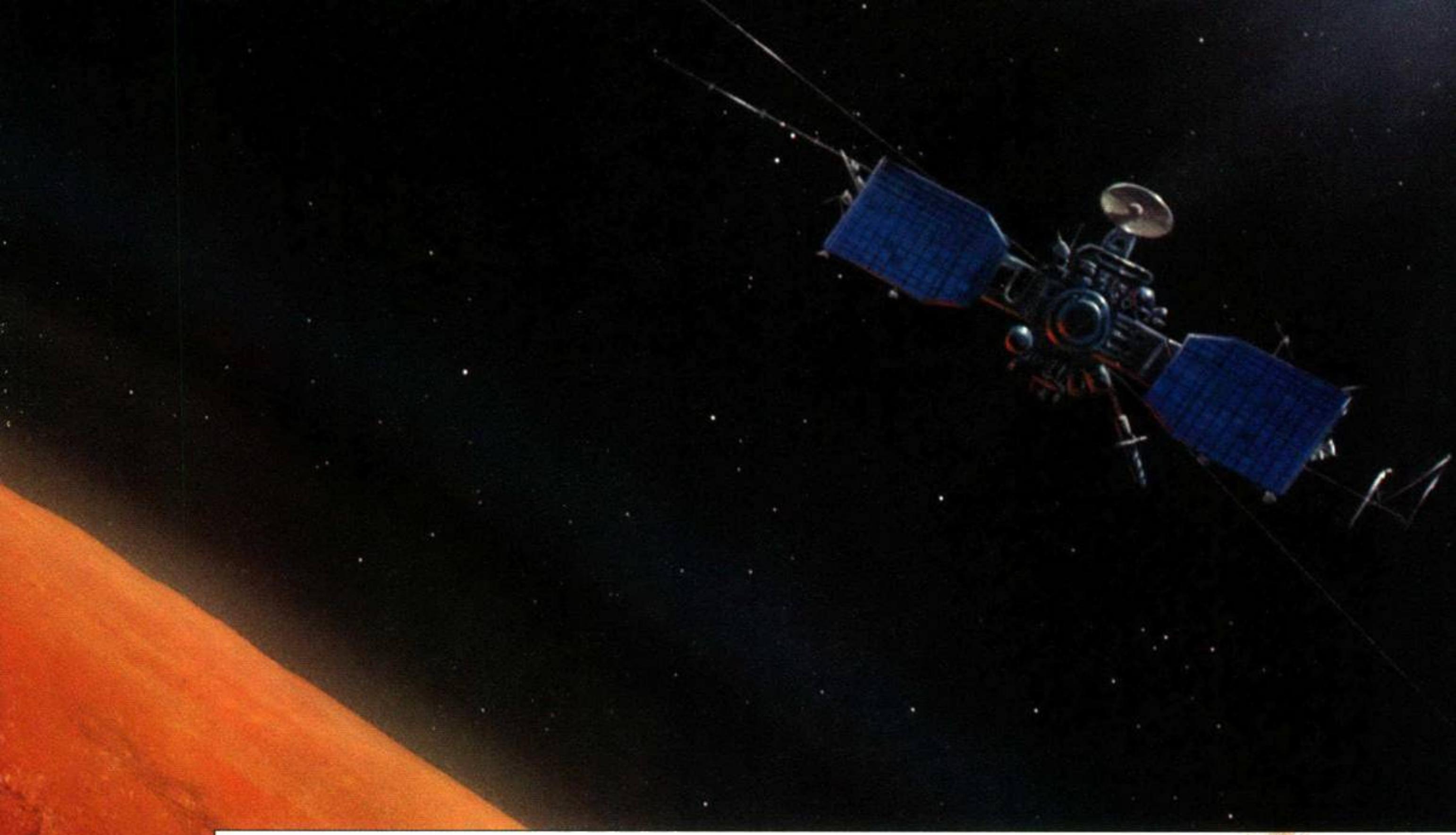


MARS '94 KICKS OFF an ambitious few years of Mars exploration by Russian space probes. Launched next year, Mars '94 will place an orbiter around Mars and two small landers (inset) and two penetrators on its surface.



Michael Carroll

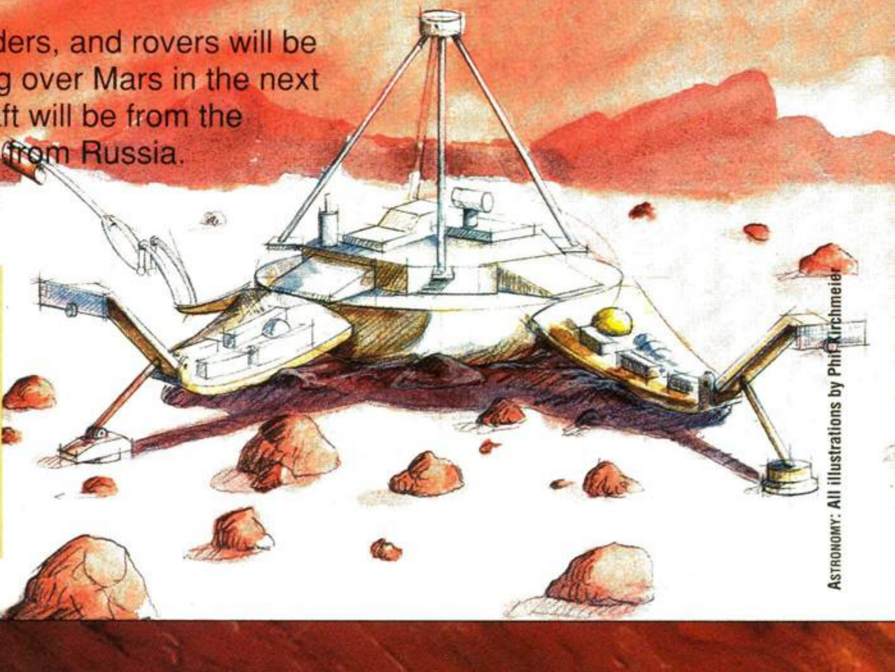
RETURN TO THE RED PLANET

MARS:
the Russians are going! the Russians are going!

An armada of orbiters, landers, and rovers will be flying, floating, and roaming over Mars in the next few years. Some of the craft will be from the United States. Most will be from Russia.

by Michael Carroll

Mars '94 Lander
Country of origin: Russia
Part of Mars '94 mission
(includes one orbiter)
Launch: September 1994
Arrival: August 1995
Mission: Measure Martian surface properties and weather conditions



ASTRONOMY: All illustrations by Phil Kirchmeier

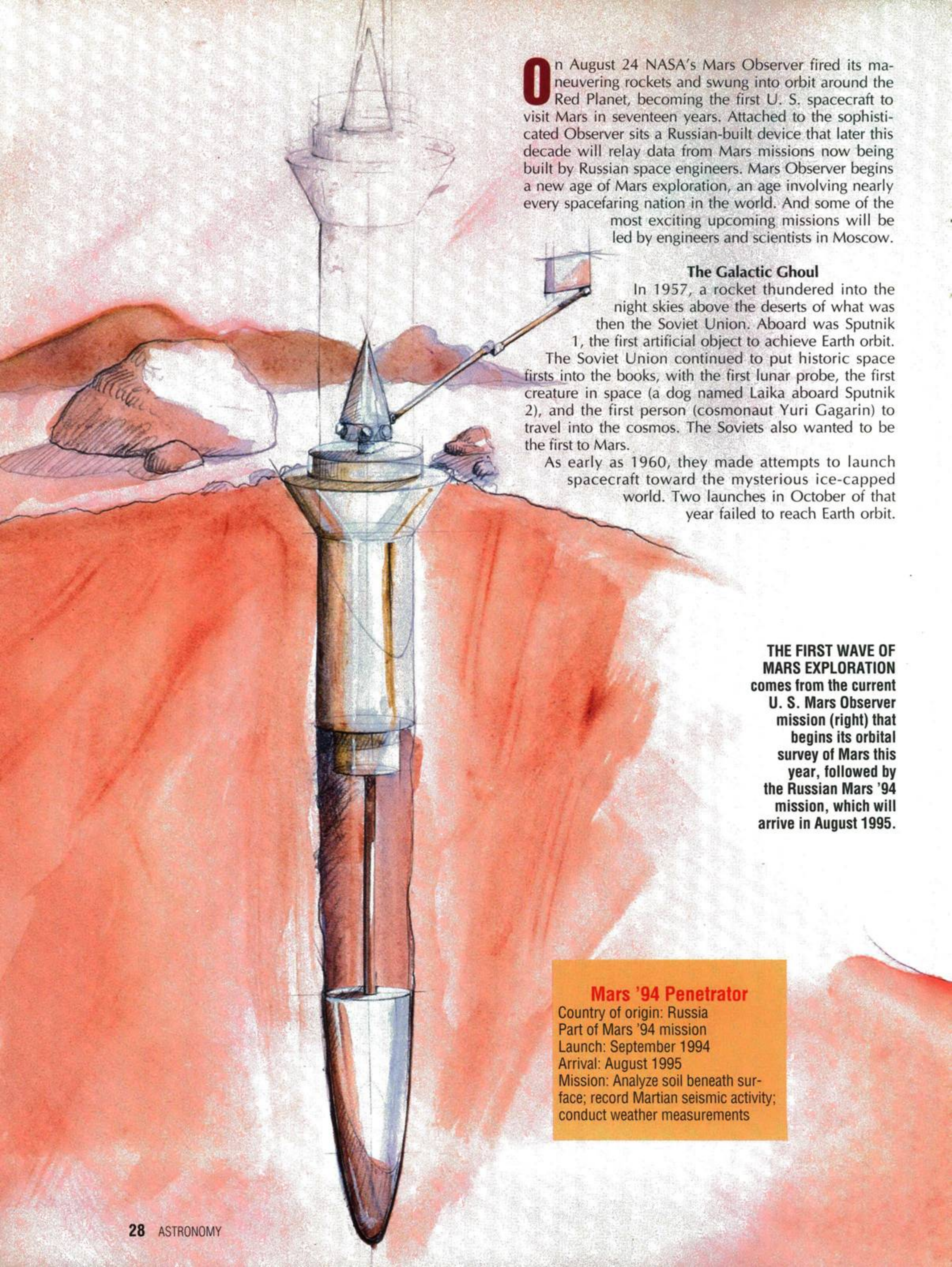
On August 24 NASA's Mars Observer fired its maneuvering rockets and swung into orbit around the Red Planet, becoming the first U. S. spacecraft to visit Mars in seventeen years. Attached to the sophisticated Observer sits a Russian-built device that later this decade will relay data from Mars missions now being built by Russian space engineers. Mars Observer begins a new age of Mars exploration, an age involving nearly every spacefaring nation in the world. And some of the most exciting upcoming missions will be led by engineers and scientists in Moscow.

The Galactic Ghoul

In 1957, a rocket thundered into the night skies above the deserts of what was then the Soviet Union. Aboard was Sputnik 1, the first artificial object to achieve Earth orbit.

The Soviet Union continued to put historic space firsts into the books, with the first lunar probe, the first creature in space (a dog named Laika aboard Sputnik 2), and the first person (cosmonaut Yuri Gagarin) to travel into the cosmos. The Soviets also wanted to be the first to Mars.

As early as 1960, they made attempts to launch spacecraft toward the mysterious ice-capped world. Two launches in October of that year failed to reach Earth orbit.



THE FIRST WAVE OF MARS EXPLORATION comes from the current U. S. Mars Observer mission (right) that begins its orbital survey of Mars this year, followed by the Russian Mars '94 mission, which will arrive in August 1995.

Mars '94 Penetrator

Country of origin: Russia
Part of Mars '94 mission
Launch: September 1994
Arrival: August 1995
Mission: Analyze soil beneath surface; record Martian seismic activity; conduct weather measurements

The world was then immersed in the Cold War and Soviet officials kept both failures secret. On October 24, 1962, a Mars-bound craft reached Earth orbit but was stranded there. Soviets gave the world the same silent treatment.

But on November 1, 1962, it looked as if a successful Soviet Mars mission was finally underway. Designated Mars 1, the craft was set to fly by Mars the following June. Just ten weeks before the encounter, contact was mysteriously lost. Some scientists were beginning to wonder if a craft could be successfully sent that far into space.

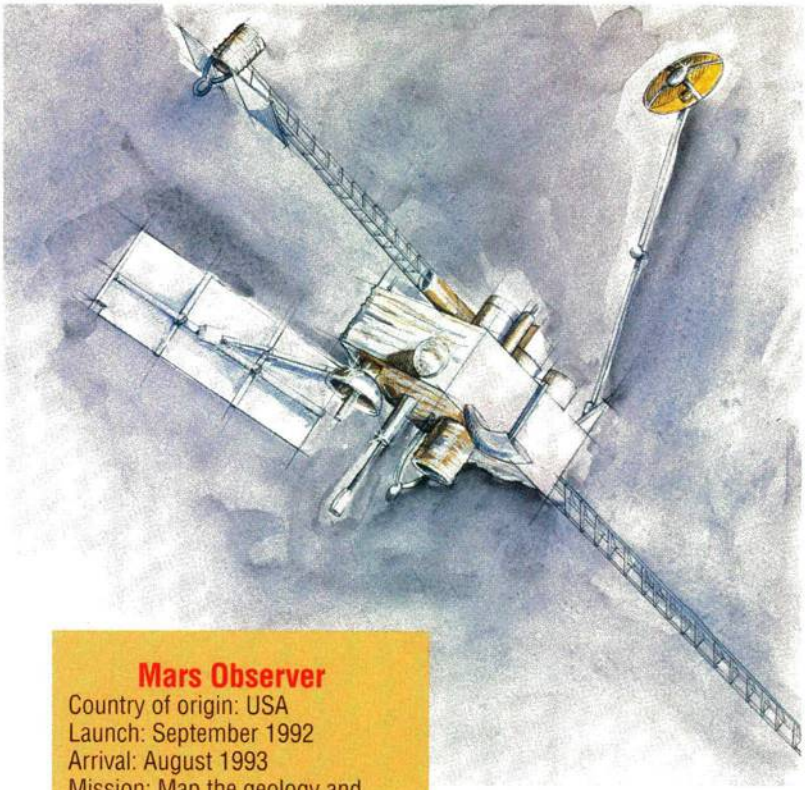
Three years later the Soviets were ready to try again. Zond 2 was to be a flyby of Mars and may have contained a lander. But in April 1965, contact with the probe was lost before it reached Mars. American scientists joked about a Great Galactic Ghoul lying in wait to ambush unsuspecting spacecraft. They laughed nervously, however — the first U. S. attempt was also on its way.

NASA's Mariner 3 made it into space on November 5, 1964, but its protective shroud failed to open, trapping the spacecraft inside. Three weeks later its twin, Mariner 4, sped away toward Mars without incident. In July 1965, the probe carried out the first successful flyby of the Red Planet, sneaking past the Galactic Ghoul to return 22 pictures of the cratered surface of Mars. Four years later, Mariners 6 and 7 flew past Mars, returning two hundred images. Then in 1971, NASA's Mariner 9 became the first probe to orbit Mars.

The Soviets countered with their Mars 2 and 3 craft. These were missions designed not just to fly past or orbit Mars but to land. In 1971, arriving only two weeks after Mariner 9, the Mars 2 and Mars 3 mother ships entered Martian orbit. A raging dust storm shrouded the planet. Unfortunately, the landers had already been automatically deployed. Mars 2 crashed but became the first human-made craft to touch the red soil of Mars. Mars 3 landed successfully.

Only recently have Russian scientists revealed that both the Mars 2 and 3 landers contained the first Mars rovers, designed to scoot over the sand and test the soil. With Mars 2 lost, the mission rested on the success of the Mars 3 probe. After reaching the surface, the lander began to transmit the first image of the Martian landscape. This was five years before the U. S. Viking missions, which placed two landers on Mars in 1976.

But excitement turned to frustration. After only twenty seconds, the lander went silent. Its ride-along rover never got a chance to roam the Martian sands. Nevertheless, the first rover had arrived at Mars. Others were sure to follow.



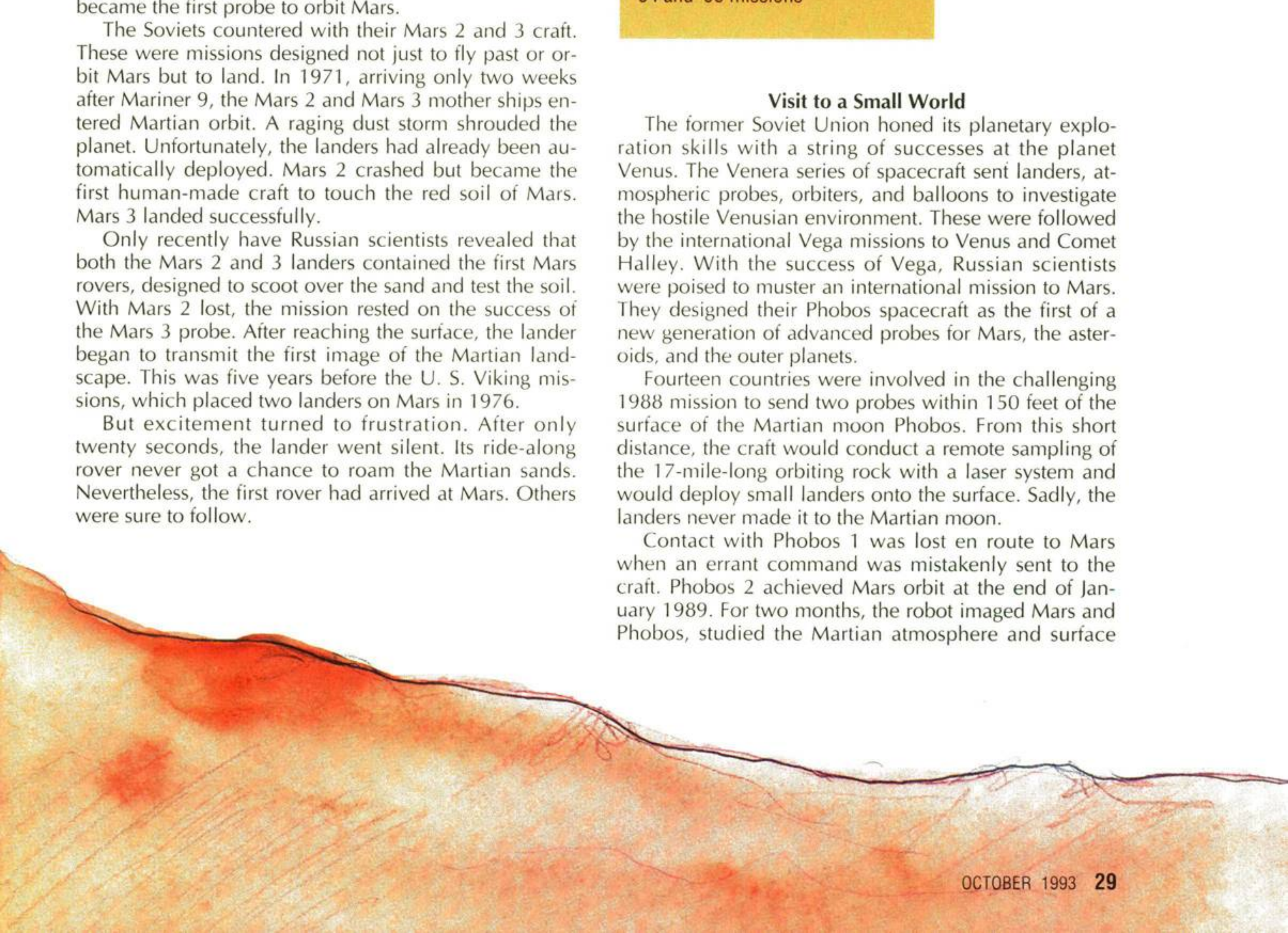
Mars Observer
Country of origin: USA
Launch: September 1992
Arrival: August 1993
Mission: Map the geology and climate of Mars from orbit; act as relay station for Russian Mars '94 and '96 missions

Visit to a Small World

The former Soviet Union honed its planetary exploration skills with a string of successes at the planet Venus. The Venera series of spacecraft sent landers, atmospheric probes, orbiters, and balloons to investigate the hostile Venusian environment. These were followed by the international Vega missions to Venus and Comet Halley. With the success of Vega, Russian scientists were poised to muster an international mission to Mars. They designed their Phobos spacecraft as the first of a new generation of advanced probes for Mars, the asteroids, and the outer planets.

Fourteen countries were involved in the challenging 1988 mission to send two probes within 150 feet of the surface of the Martian moon Phobos. From this short distance, the craft would conduct a remote sampling of the 17-mile-long orbiting rock with a laser system and would deploy small landers onto the surface. Sadly, the landers never made it to the Martian moon.

Contact with Phobos 1 was lost en route to Mars when an errant command was mistakenly sent to the craft. Phobos 2 achieved Mars orbit at the end of January 1989. For two months, the robot imaged Mars and Phobos, studied the Martian atmosphere and surface



chemistry, and searched for magnetic fields. Each orbit brought it closer to Phobos. On March 27, while the craft was doing a final reconnaissance of the little moon prior to its encounter, Phobos 2 was lost. Clearly, Russian scientists still needed to resolve some serious technical problems.

Despite its limited success, Phobos paved the way for a new series of Russian Mars explorers now being built at scientific centers around the world. The project, called Mars '94/'96, may turn out to be the most exciting Mars exploration of the decade.

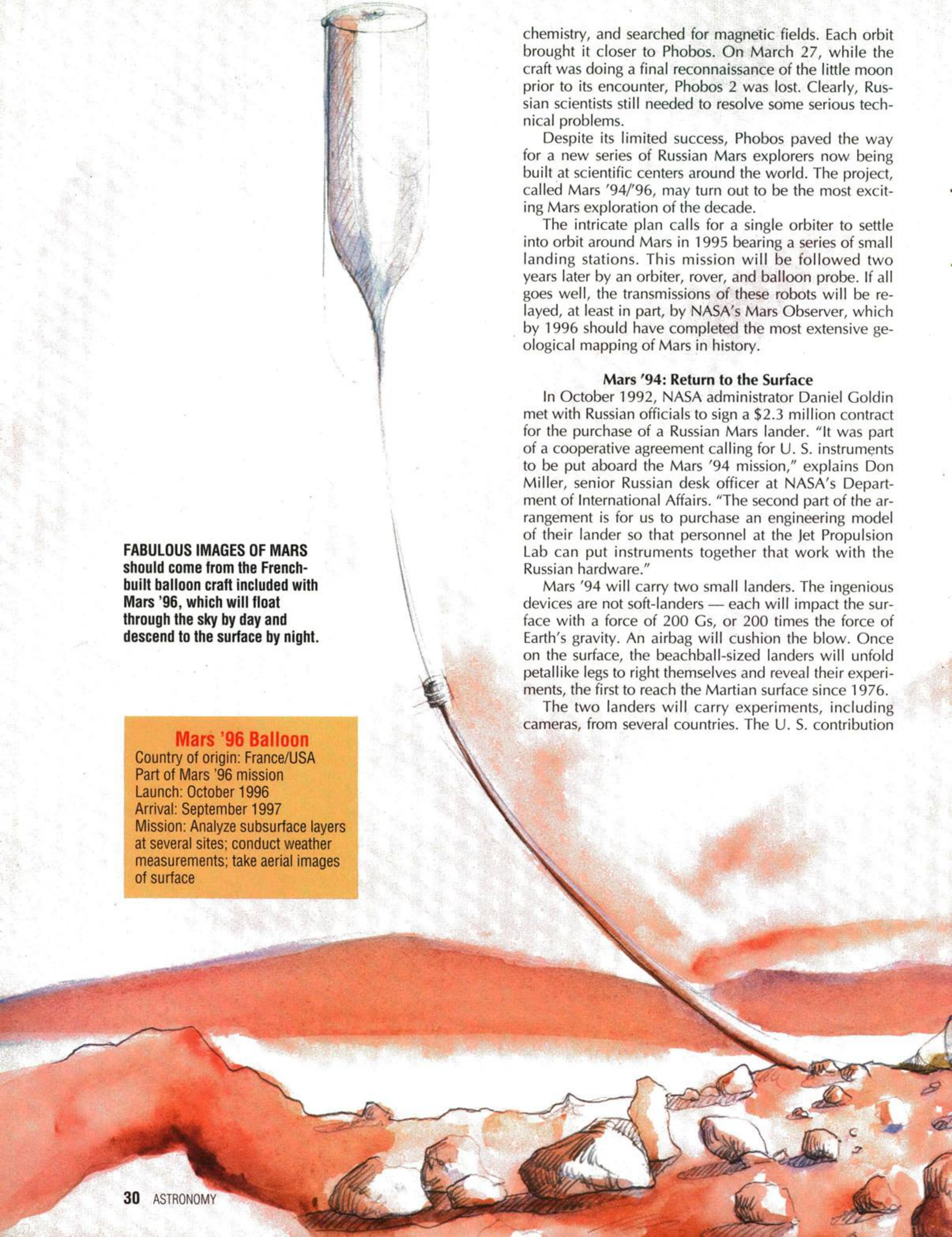
The intricate plan calls for a single orbiter to settle into orbit around Mars in 1995 bearing a series of small landing stations. This mission will be followed two years later by an orbiter, rover, and balloon probe. If all goes well, the transmissions of these robots will be relayed, at least in part, by NASA's Mars Observer, which by 1996 should have completed the most extensive geological mapping of Mars in history.

Mars '94: Return to the Surface

In October 1992, NASA administrator Daniel Goldin met with Russian officials to sign a $2.3 million contract for the purchase of a Russian Mars lander. "It was part of a cooperative agreement calling for U. S. instruments to be put aboard the Mars '94 mission," explains Don Miller, senior Russian desk officer at NASA's Department of International Affairs. "The second part of the arrangement is for us to purchase an engineering model of their lander so that personnel at the Jet Propulsion Lab can put instruments together that work with the Russian hardware."

Mars '94 will carry two small landers. The ingenious devices are not soft-landers — each will impact the surface with a force of 200 Gs, or 200 times the force of Earth's gravity. An airbag will cushion the blow. Once on the surface, the beachball-sized landers will unfold petallike legs to right themselves and reveal their experiments, the first to reach the Martian surface since 1976.

The two landers will carry experiments, including cameras, from several countries. The U. S. contribution



FABULOUS IMAGES OF MARS **should come from the French-built balloon craft included with Mars '96, which will float through the sky by day and descend to the surface by night.**

Mars '96 Balloon

Country of origin: France/USA
Part of Mars '96 mission
Launch: October 1996
Arrival: September 1997
Mission: Analyze subsurface layers at several sites; conduct weather measurements; take aerial images of surface

called the Mars Oxidant Experiment will extend from each of the landers on a short boom. MOX consists of a fiber optics bundle that will touch the surface of Mars in a search for the chemicals that caused Mars' soil to rust.

In addition to the landers, Mars '94 will also include two penetrators. These spearlike devices will drop at over 300 miles per hour carrying seismometers and other instruments to a depth of several meters. Each penetrator will split into two — the bottom half of the spear shooting into the ground and the top half with weather instruments and a camera remaining above ground.

Russian officials have tentatively narrowed the four Mars '94 landing sites to areas west, southwest, and northwest of Olympus Mons, according to Aleksandr Basilevsky of the Vernadsky Institute in Moscow. "The landers and penetrators release before the orbiter arrives," Basilevsky explains. "They spread out across the surface like a cone. We want the sites to have diverse geology, but they also need to be safe for landing."

Mars '94 is scheduled for launch a year from now, in September 1994. Arrival at Mars will come 11 months later just as Mars Observer is finishing its first Martian year of mapping from orbit.

Mars '96: A Beautiful Balloon

The ambitious scope of Mars '94 is dwarfed by what is to follow. The international Mars '96 program headed by Moscow's Institute for Space Research calls for a massive orbiter to deploy both a rover and a balloon probe. "Mars '96 is by far the most complex Mars mission to date," says Louis Friedman, executive director of the Planetary Society, a private U. S.-based organization that has been contributing money and personnel toward the development of the rover and balloon probe.

The Mars '96 mission involves sending a single spacecraft into orbit around the Red Planet in September 1997. Once in orbit and after a final reconnaissance of the surface, the craft will release a massive package in an aeroshell that will protect the rover and balloon from the heat of entry as it hits the atmosphere at 8,900 miles per hour. Once the craft reaches the lower atmosphere, a timer releases a parachute that pulls the rover out of the aeroshell. Cushioned by a wrap-around airbag, the rover begins its parachute descent to the surface. After landing, the rover unfolds and begins its exploration. It is completely self-contained — there is no lander for it to return to.

In the meantime, another parachute pulls the balloon probe from the shell. When its speed has slowed sufficiently, the balloon gradually inflates with helium, blossoming to its full 140-foot length. The parachute jettisons at 10,000 feet, the cruising altitude of the balloon.

From its high viewpoint, the balloon will measure wind, temperature, and pressure. It also carries a camera system to take what promise to be spectacular aerial photographs of the Martian surface below. But the balloon is even more clever than first meets the eye. By day, the heat from the Sun will aid the craft's buoyancy. After the Sun sets, air temperatures on Mars can drop by nearly 100° F. In the cold night air, the balloon slowly descends. As it approaches the ground, a long guide rope called the Snake comes to rest on the surface. The balloon remains in the air while the Snake, acting like a stabilizing anchor, drags along the ground. Its segmented design should prevent it from becoming snagged.

The Snake also acts as an antenna for an experiment on the balloon that will beam radar signals off whatever lies beneath the Martian surface. At the moment, the Snake itself contains no instruments. Early plans called for it to carry a gamma-ray spectrometer to analyze the soil, an experiment that may yet find a place on the final version of the Snake.

The following morning, as the Sun warms the air, the balloon heats up, ascends to cruising altitude, and continues its aerial reconnaissance. Scientists expect the battery-powered balloon to survive for at least a week, returning information on the Martian surface from a wide area.

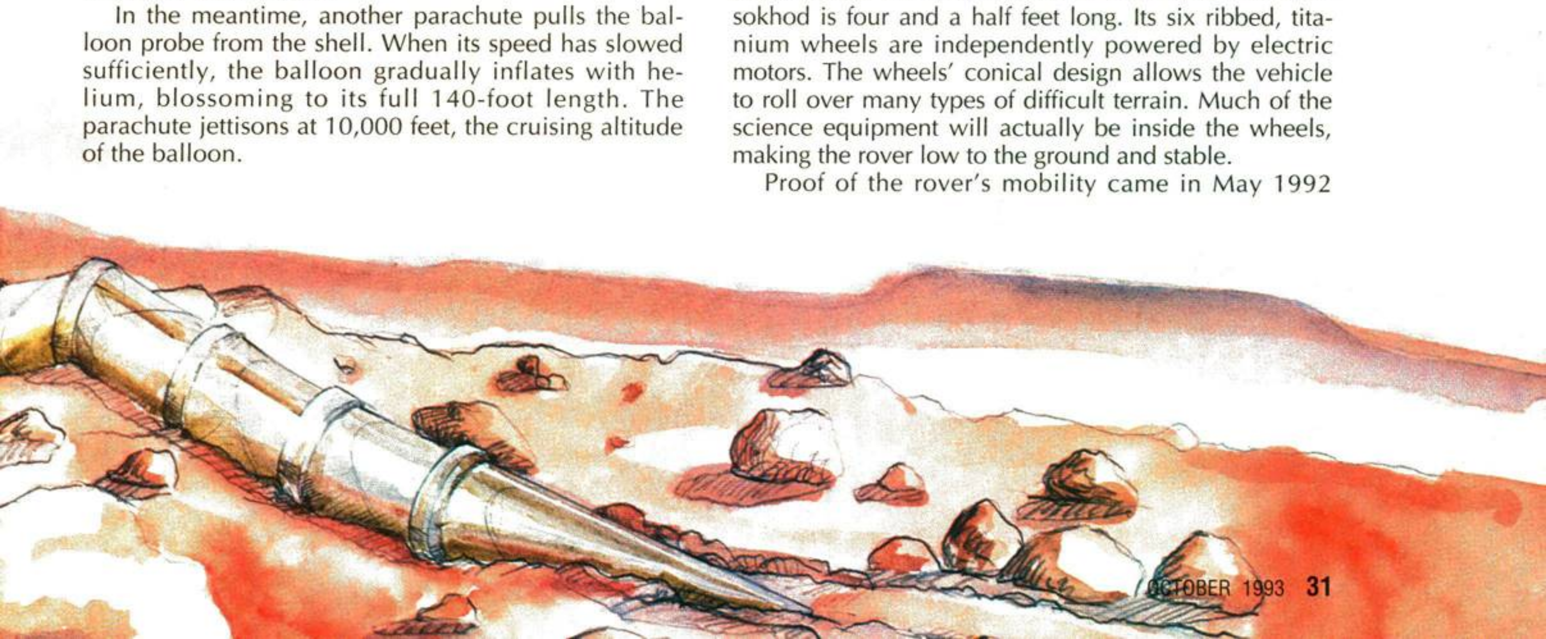
The French space agency, the Centre National d'Études Spatiales, is building the balloon, although the balloon's gondola will house instruments from several countries. Chief designer of the balloon is Jacques Blamont, who was also responsible for the successful Venus balloons on the 1986 Soviet Vega project.

The seed money for developing the Snake came from the member-supported Planetary Society, making it the first privately sponsored planetary exploration in history. "A lot of interest has been generated by the balloon project," remarks Louis Friedman, "but I think a full understanding of just what an accomplishment this is has not caught on . . . yet."

Driving the Sands of Mars

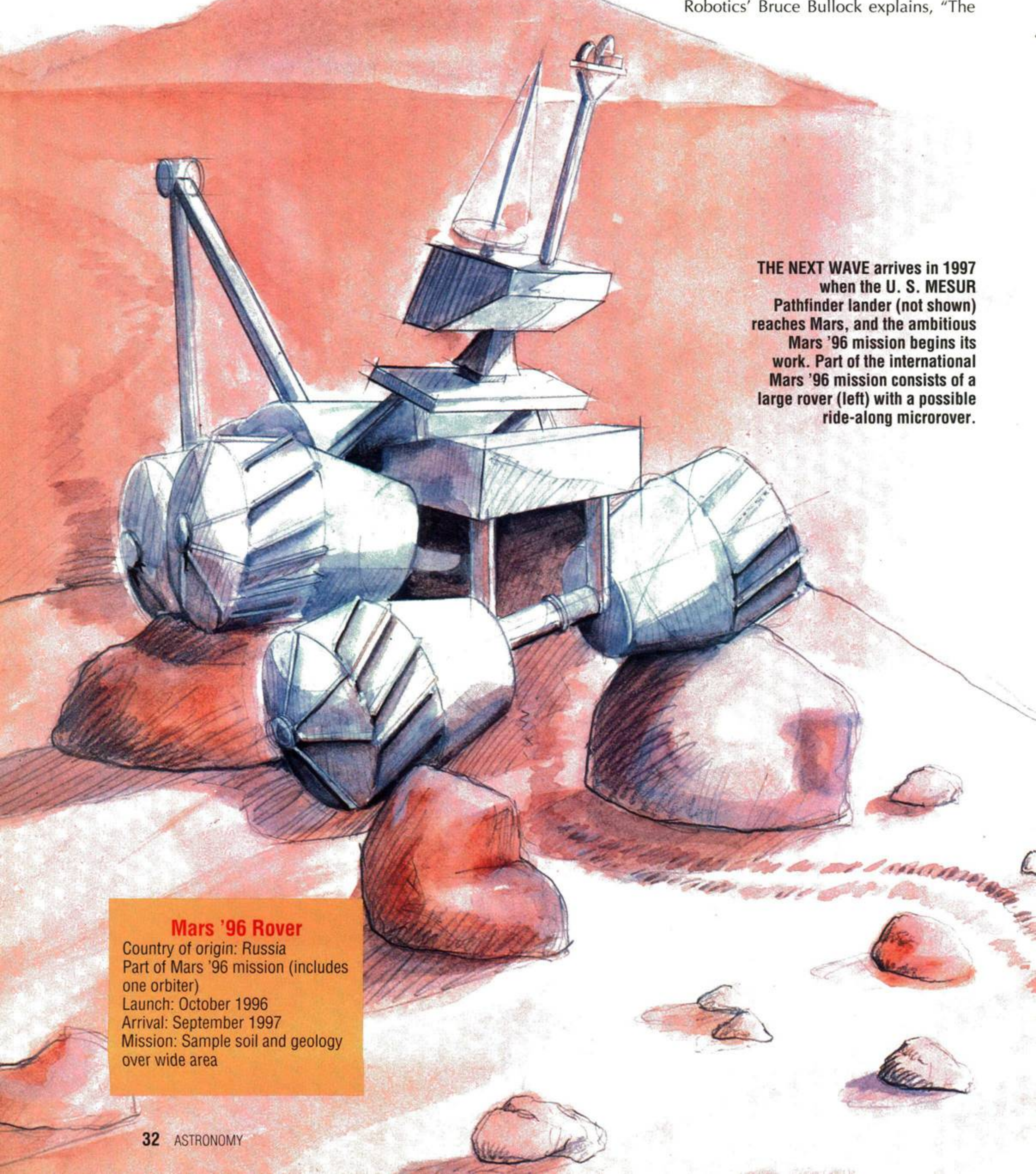
The second novel element of Mars '96 is the rover, a six-wheeled 150-pound vehicle being built in St. Petersburg, Russia, by VNIIT Transmash (the Mobile Engineering Institute). Transmash built the Lunokhods, which drove across the lunar surface in the 1970s. The Marsokhod is four and a half feet long. Its six ribbed, titanium wheels are independently powered by electric motors. The wheels' conical design allows the vehicle to roll over many types of difficult terrain. Much of the science equipment will actually be inside the wheels, making the rover low to the ground and stable.

Proof of the rover's mobility came in May 1992



when scientists and engineers from Russia, France, Hungary, and the United States met in Death Valley, California, for a series of Planetary Society-sponsored tests of the Russian rover design. Mission planners chose Death Valley as a test site because it provided a range of Mars-like surfaces for the rover to tackle. The rover demonstrated its ability to avoid dangerous terrain and to back out of potentially disastrous situations.

Also present at the Death Valley tests were representatives of I. S. Robotics, a California company that manufactures small industrial robots called microrovers. I. S. Robotics brought three microrovers that could be mounted atop the larger Russian rover. As I. S. Robotics' Bruce Bullock explains, "The



THE NEXT WAVE arrives in 1997 when the U. S. MESUR Pathfinder lander (not shown) reaches Mars, and the ambitious Mars '96 mission begins its work. Part of the international Mars '96 mission consists of a large rover (left) with a possible ride-along microrover.

Mars '96 Rover
Country of origin: Russia
Part of Mars '96 mission (includes one orbiter)
Launch: October 1996
Arrival: September 1997
Mission: Sample soil and geology over wide area

smaller rover can be sent to areas where the large Russian rover can't reach, like narrow canyons or rough terrain. It can then return with samples."

Three years ago, Russian space engineers expressed interest in a U. S.-built "sample acquisition device" such as a soil scoop or drill. They alotted five kilograms of payload weight for the device. But the Cold War was just winding down, and the political atmosphere was not conducive to any official NASA commitment. At that time, the Planetary Society's Louis Friedman acted as a liaison between the then Soviet Union and private companies such as I. S. Robotics. "It turns out that if you intend to plug a piece of U. S. hardware into a Russian one, suddenly you're saddled with incredible export restrictions, even now," says Bullock. "Building an arm would not have been workable." Instead, the robotics company suggested a five kilogram autonomous microrover.

Designers of the microrover have narrowed their choices to one of two designs: a six-wheeled device or a six-legged walker. "The Russians have always been intrigued by the legged vehicle," Bullock explains. "It has some advantages for obstacle negotiation and traction, but it's a toss-up right now as to which one will be the final choice." In addition to remote sampling, the little rover can serve as a video scout, assessing the risky paths ahead of the larger Russian vehicle. If the big rover gets stuck, the microrover can provide video from other vantage points to help the craft steer clear.

Whether a U. S.-made rover will make the trip on Mars '96 is still up in the air. Bullock explains the situation: "The Russians are sitting there with the potential to launch this thing. In the past, NASA has not been able to move officially for security and political reasons. The Planetary Society helped to nudge things along, but once the Cold War was past, changes took place. NASA is warming to the idea. The question is, who will build the microrover?" Will it be I. S. Robotics or NASA?

Since 1985, Jet Propulsion Laboratory's Donna Pivirotto has been working on U. S. planetary rovers. She now manages JPL's microrover programs. According to Pivirotto, JPL's sophisticated Rocky IV vehicle could be modified to fill the bill. JPL is developing Rocky IV for NASA's upcoming MESUR missions to Mars. A Rocky IV might be included with the first MESUR mission, called Pathfinder, tentatively scheduled to land on Mars in mid to late 1997, the same year Mars '96 arrives. Will Mars '96 also carry a Rocky IV piggybacked on the large Russian rover?

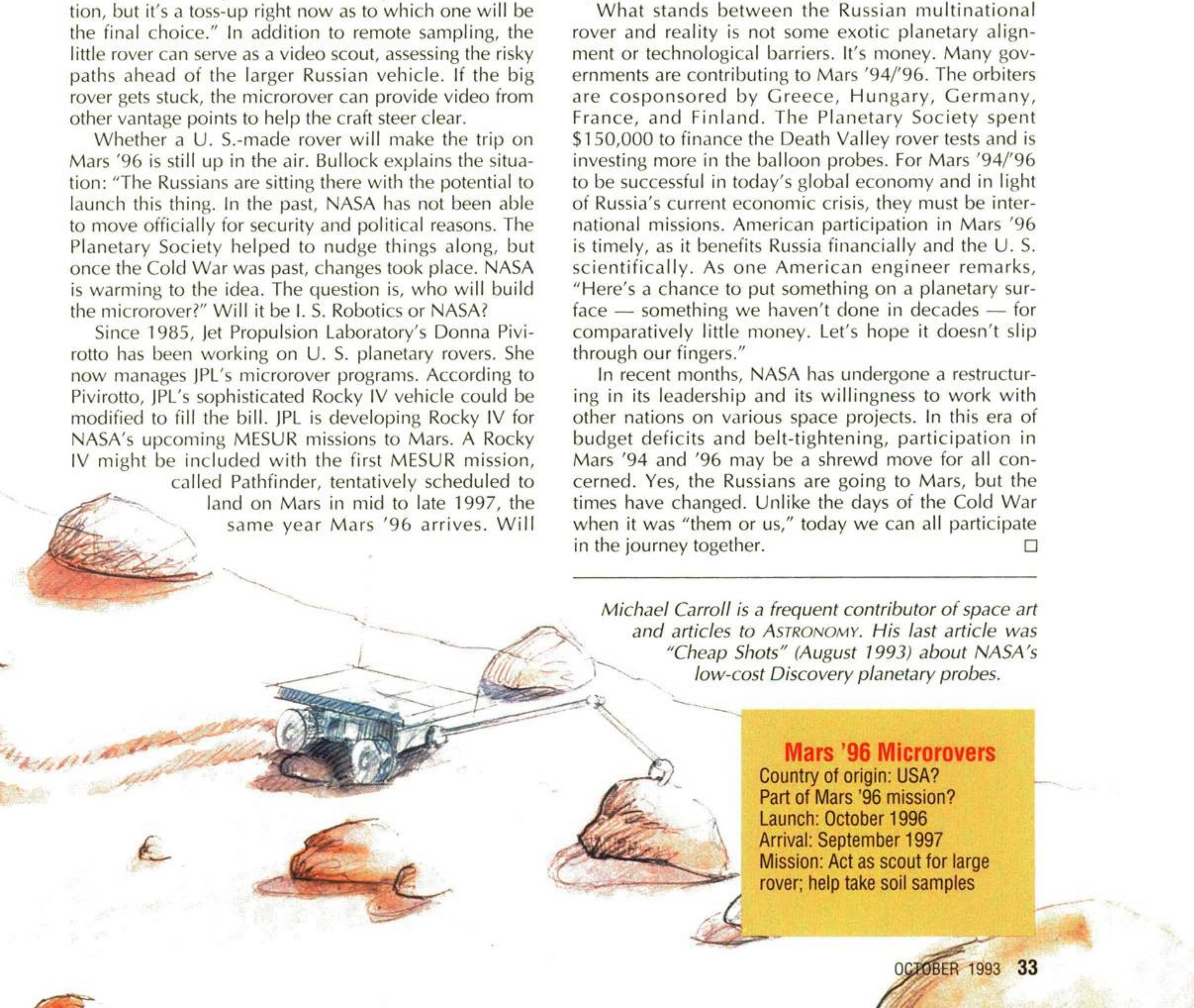
"Our rover is the size that could be flown," says Pivirotto but stresses that NASA and the Russians haven't started any official negotiations about flying U. S. hardware on the Mars '96 mission. But as Bruce Bullock puts it, "Russia is probably tickled pink that NASA is at least now picking up the phone and returning their faxes. My guess is that the first microrover on a Russian Mars rover will be built by NASA/JPL. They have the knowledge to move to a space-ready version quickly."

It might be useful to have other microrovers ride along if they complement JPL's design, since there may still be room. A good candidate would be I. S. Robotics' walker. "Unfortunately, the Russians can't afford to support development of a space-ready version of our rover," says Bullock. "If NASA decreases its support of microrovers at JPL for budgetary reasons, the U. S. could miss the Mars mission altogether. That would be tragic. If it came to that, rather than have the U. S. miss another opportunity where it has pioneered and led the technology, it might be worth finding philanthropic support to fly microrovers from private companies."

What stands between the Russian multinational rover and reality is not some exotic planetary alignment or technological barriers. It's money. Many governments are contributing to Mars '94/'96. The orbiters are cosponsored by Greece, Hungary, Germany, France, and Finland. The Planetary Society spent $150,000 to finance the Death Valley rover tests and is investing more in the balloon probes. For Mars '94/'96 to be successful in today's global economy and in light of Russia's current economic crisis, they must be international missions. American participation in Mars '96 is timely, as it benefits Russia financially and the U. S. scientifically. As one American engineer remarks, "Here's a chance to put something on a planetary surface — something we haven't done in decades — for comparatively little money. Let's hope it doesn't slip through our fingers."

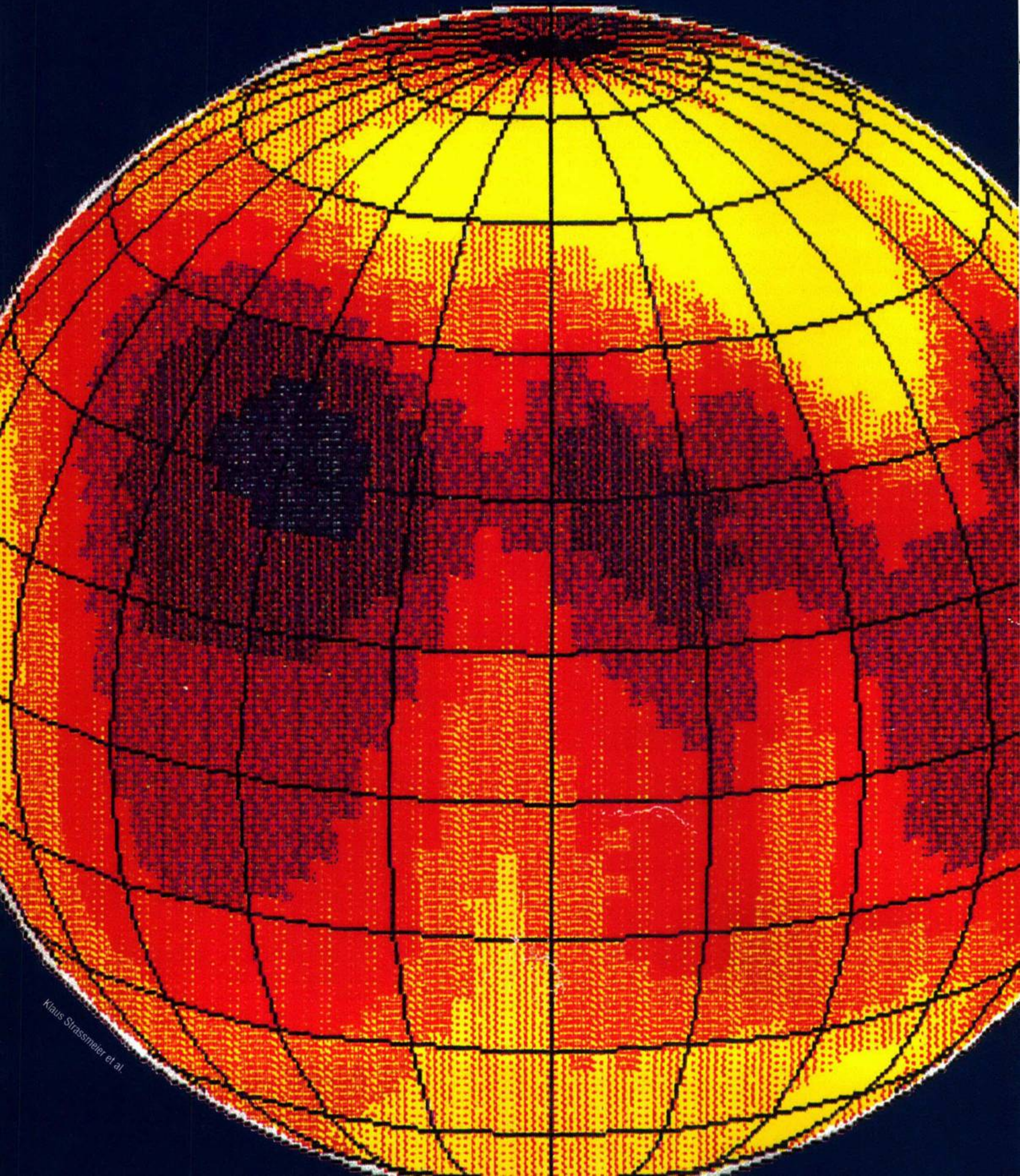
In recent months, NASA has undergone a restructuring in its leadership and its willingness to work with other nations on various space projects. In this era of budget deficits and belt-tightening, participation in Mars '94 and '96 may be a shrewd move for all concerned. Yes, the Russians are going to Mars, but the times have changed. Unlike the days of the Cold War when it was "them or us," today we can all participate in the journey together. □

Michael Carroll is a frequent contributor of space art and articles to ASTRONOMY. *His last article was "Cheap Shots" (August 1993) about NASA's low-cost Discovery planetary probes.*



Mars '96 Microrovers

Country of origin: USA?
Part of Mars '96 mission?
Launch: October 1996
Arrival: September 1997
Mission: Act as scout for large rover; help take soil samples



Klaus Strassmeier et al.

Seeing a Star's Surface

Even the world's largest telescopes can't resolve details on the surface of a star other than the Sun. Instead, astronomers use a star's rotation to unveil its features.

by David Bruning

Every astronomer at one time or another has looked at a star through a telescope, trying to magnify the image more and more to glimpse the star's disk. And everyone becomes disheartened because no matter how hard they try, they can't see the star's disk. Even the closest stars, like Alpha Centauri, appear no more than one-hundredth of an arcsecond across, resisting the efforts of even giant telescopes to resolve the disk.

Of course, you don't need to see spots on the surface to deduce their presence. For several decades astronomers have followed variations in the brightnesses of some stars. Setting aside those stars that vary in brightness due to pulsations or eclipses caused by a companion star, the variations imply that dark spots and bright patches called plages, both caused by magnetic fields, pop in and out of view as the star rotates. But knowing that a star is magnetically active is vastly different from knowing the details of the star's activity.

Because the youngest stars are in general also the most active stars, learning about stellar activity will help astronomers better understand how stars age. Closer to home, solar activity is important because it's related to the heating of Earth's atmosphere and long-term changes in Earth's climate. To predict how our climate changes, scientists need a good model of how the Sun generates its magnetic fields. But so far these models have proven inadequate. Mapping the surfaces of stars with their dark spots is an essential step in building better theories about the generation of stellar — and solar — magnetic fields.

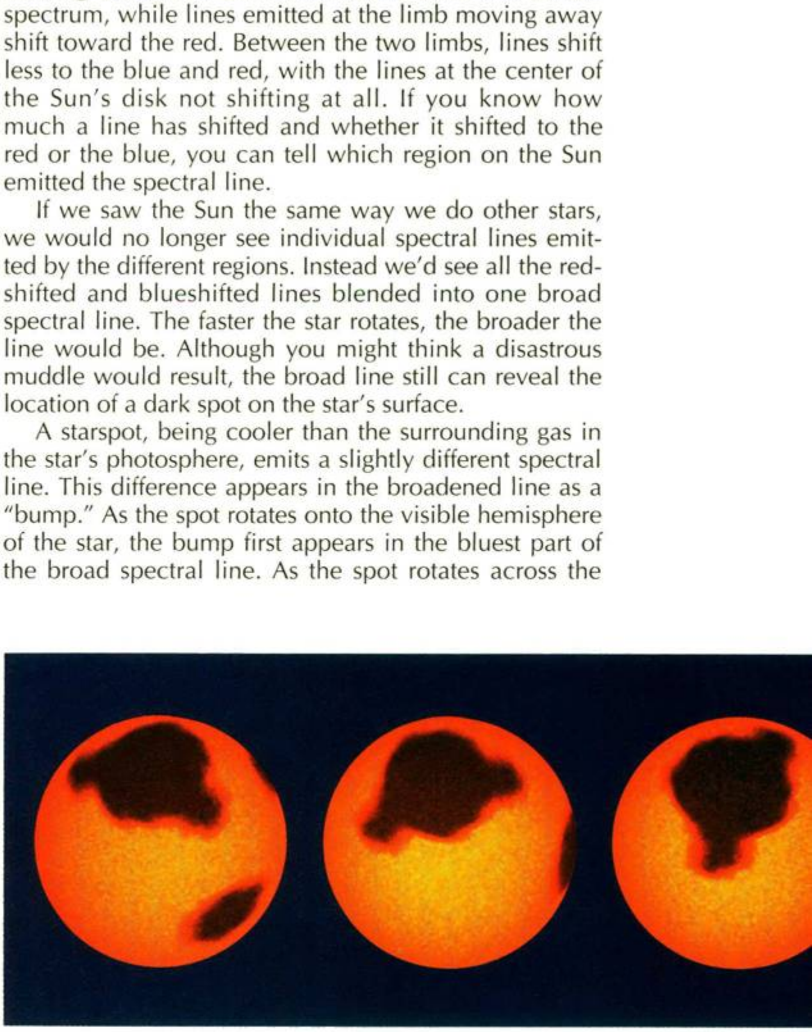
Imaging an Unseen Surface

To get stars to reveal what lies on their surfaces, stellar astronomers have resorted to trickery. They cajole the stellar secrets by studying variations in a star's spectrum and brightness, using the star's own rotation to betray the presence of dark spots, bright plages, magnetic fields, and regions of peculiar chemical composition. Doppler imaging, as researchers call it, uses the shifting in spectral-line wavelength caused by the star's rotation.

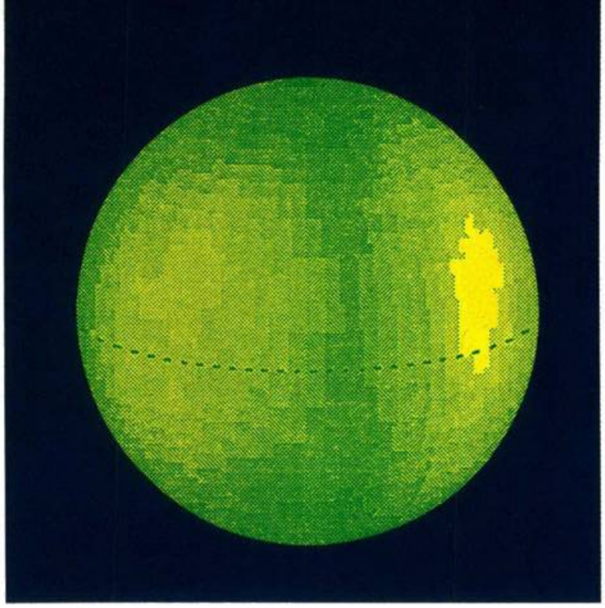
To see how Doppler imaging works, consider the surface or photosphere of our star. Rotation causes one limb, or edge, of the Sun to move toward us and the other to move away. Spectral lines emitted at the limb moving toward us shift toward the blue end of the spectrum, while lines emitted at the limb moving away shift toward the red. Between the two limbs, lines shift less to the blue and red, with the lines at the center of the Sun's disk not shifting at all. If you know how much a line has shifted and whether it shifted to the red or the blue, you can tell which region on the Sun emitted the spectral line.

If we saw the Sun the same way we do other stars, we would no longer see individual spectral lines emitted by the different regions. Instead we'd see all the redshifted and blueshifted lines blended into one broad spectral line. The faster the star rotates, the broader the line would be. Although you might think a disastrous muddle would result, the broad line still can reveal the location of a dark spot on the star's surface.

A starspot, being cooler than the surrounding gas in the star's photosphere, emits a slightly different spectral line. This difference appears in the broadened line as a "bump." As the spot rotates onto the visible hemisphere of the star, the bump first appears in the bluest part of the broad spectral line. As the spot rotates across the



VIEWING DARK SPOTS on the surface of a star, such as solarlike LQ Hydrae, is no longer a dream of astronomers. A new technique called Doppler imaging permits them to map spots (black) and bright patches called plages (yellow).



Steve Saar, Nikolai Piskunov, and Ilkka Tuominen

MAPS OF MAGNETIC FIELDS REVEAL that the strongest fields (green) on LQ Hydrae don't lie in the dark spot regions but in bright plage regions.

face of the star, the bump becomes less blueshifted as the spot approaches the center of the stellar disk. Then the bump starts to redshift as the spot moves toward the other limb and eventually disappears as the spot passes to the invisible side of the star.

By watching a star's changing spectrum, astronomers can trace bumps as they move through a line from blue to red. They know what positions in the line correspond to what longitudes, and the brightness of the bump combined with stellar brightness measurements helps decipher the latitude of the spot. By watching the bump as it goes from blueshifted to redshifted, the researchers can reconstruct with certainty the latitude and longitude of the spot — and the positions of other spots if they are present. (In practice, astronomers use several spectral lines to deduce the locations of spots to reduce analysis errors.)

This procedure requires lots of telescope time to obtain the precise spectra needed to make Doppler maps of the star's surface. If the star rotates quickly, observers can obtain enough observations to cover the star's surface in a few nights. Stars that rotate slowly are more difficult because their narrow spectral lines make it hard to follow the bumps.

The mapping process also favors stars with large spots because small spots make only tiny, unobservable bumps in the spectral lines. Also, stars that produce many small spots scattered fairly evenly over the surface do not show changes in the spectral lines. So spots on these stars are effectively invisible with present methods.

The high-precision spectrometers needed to make these observations have been available only in the last decade, so the number of mapped stars is low. The conditions needed to map spots — fast rotation rate, variations in brightness, and large spots — also have conspired to keep the number of mapped stars low. The best examples so far are the RS Canum Venaticorum (RS CVn) stars.

When Are Spots Like Zebras?

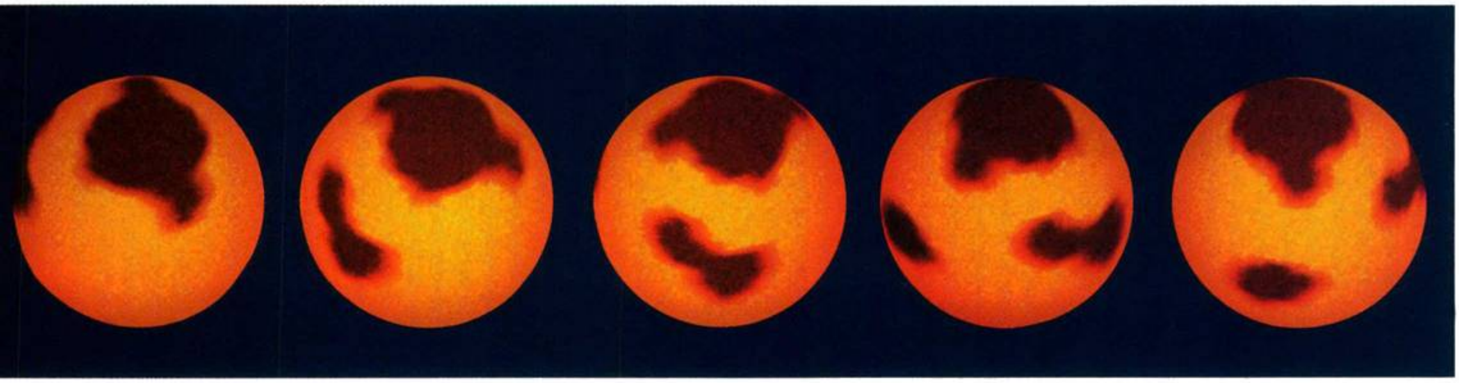
RS CVn (pronounced Ar-Ess-Kan-Ven or Ar-Ess-See-Vee-En) stars are named after the prototype of this group of variable stars, RS Canum Venaticorum. They are binaries; the primary star is a F-, G-, or K-type giant or subgiant star and the companion star is a normal G- or K-type main sequence or dwarf star like the Sun. The RS in RS CVn points out that these stars vary in brightness — not because the binary stars eclipse each other but because the primary star has large spots.

The spots appear to form near the equator and then slowly migrate toward the pole. This goes counter to the Sun's spots, which form at high latitudes and then migrate to the equator. The backward behavior and large size of the spots on RS CVns interest astronomers trying to explain how and why spots form on stars.

Astronomers have observed a number of RS CVns so far: EI Eridani, HR 1099, UX Arietis, HD 12545, and AR Lacertae. Typically the spots on these stars are about 1000 kelvins cooler than the surrounding photosphere, roughly the same temperature difference on our Sun between sunspots and the surrounding photosphere.

EI Eridani, a 7th-magnitude G-type subgiant, has provided an important test case for mappers. Four different research groups with different mapping techniques have mapped the surface of this star. While not all the methods produce exactly the same results, all showed polar spots. This dispelled some suspicions that the mapping methods weren't locating real surface features. Any method can produce some erroneous features, but the features shown by all four methods must be real.

Of course, the groups' efforts don't solve the so-called zebra problem. Are we looking at normal photo-



A STAR'S ROTATION PERMITS astronomers to translate bumps in the star's spectrum into spot locations. Many stars, like HR 1099 shown here, have large spots at the poles, unlike the Sun, where spots group near its equator.

Steve Vogt and Don Penrod

sphere over most of the star with a dark spot at the pole? Or are we seeing normal photosphere at the pole with a bright magnetic feature at the equator? White-on-black or black-on-white?

To solve the zebra problem, Larry Ramsey and Harold Nations of Pennsylvania State University searched HR 1099 (a 6th-magnitude K-type subgiant with a solarlike G2 dwarf companion) for other signs of starspots. They found that when HR 1099 showed its supposed spots, the spectral signature of titanium oxide was also present. Titanium oxide is a common ingredient in sunspots (and white paint) but it doesn't normally appear in RS CVn stars at all. So its presence confirmed that the stars indeed have dark spots.

Different Rotation

UX Arietis is another RS CVn star that has revealed an important clue as to how spots form on stars. Steve Vogt of Lick Observatory in California and Artie Hatzes, now at the University of Texas, tracked UX Arietis for five months and found several spots on its surface that changed during this interval. More importantly they could measure the rotation rates of the spots at several latitudes. Vogt and Hatzes found that the star rotates at different rates at different latitudes.

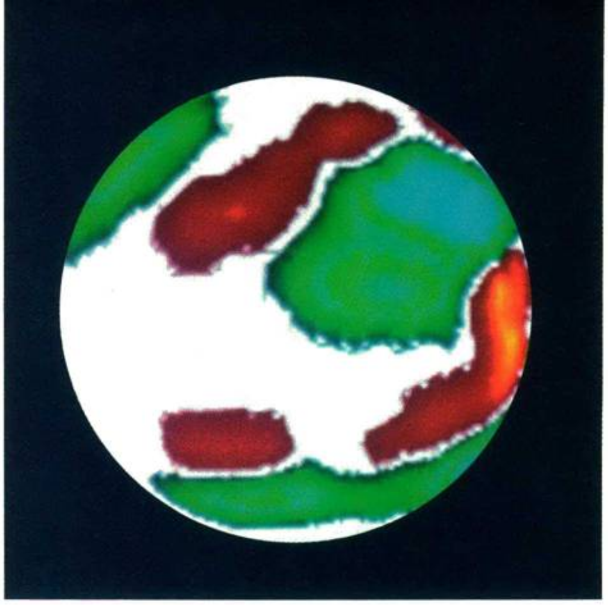
A solid ball rotates at the same rate for all latitudes. Every latitude of Earth, for example, rotates once every 24 hours. But the Sun rotates differentially, with regions at the equator rotating once every 25 days and regions near the poles rotating in about 35 days. UX Arietis rotates in about 6.4 days at the equator and slightly faster near the poles — its differential rotation goes opposite that of the Sun's.

Theorists believe that convection, the transport of energy by rising hot gases and falling cool gases, interferes with the normal rotation. The resulting differential rotation may help feed energy to the dynamo deep inside the star's interior that generates the star's magnetic fields. As important as differential rotation is, astronomers have seen it on only a few stars, including UX Arietis. Astronomers will need to observe differential rotation on many more stars before they will be able to decipher how rotation, convection, and magnetic fields interact.

Chemically Peculiar Stars

Spots on RS CVn stars aren't the only stellar features that astronomers have mapped with Doppler imaging methods. John Rice of Brandon University in Manitoba and William Whelau of the University of Western Ontario have found iron and silicon impurities across the surfaces of chemically peculiar A-type stars such as Epsilon Ursae Majoris and Theta Aurigae. Normally stars have their iron and silicon sprinkled uniformly through the atmosphere. But in peculiar A-type stars, some regions can contain up to 100 times more of these elements than other regions.

Astronomers believe the overabundance of these metallic elements in some regions results from the star's magnetic field. The star's gravity tries to pull these heavy elements toward the center while magnetic fields and light emitted within the star can force the elements to the surface. Scientists call this tug of war diffusion. Because the star's magnetic field, like that of a bar magnet, has two poles, diffusion forms rings of iron and silicon around the magnetic poles.



Artie Hatzes, Don Penrod, and Steve Vogt

MAGNETIC FIELDS CREATE PATCHES of iron and silicon (up to 100 times normal amounts), shown in red, on chemically peculiar A-type stars such as Gamma^2 Arietis.

Hatzes, along with Vogt and Don Penrod, has also looked at chemically peculiar stars, in particular 5th-magnitude Gamma^2 (γ^2) Arietis (see above). He found the magnetic field structure of Gamma^2 Arietis may be complex, which may yield important clues as to how magnetic fields aid diffusion and perhaps why these stars have strong magnetic fields.

And Dwarfs, Too

One dwarf star like the Sun has had Doppler images made of its surface, LQ Hydrae. Klaus Strassmeier of Universität Wien in Vienna, Austria, and his coworkers have mapped this 8th-magnitude K dwarf (see page 34). They find a number of spots that are a few hundred kelvins cooler than the star's photosphere, although the mapping method overestimates the temperature of the small spots of this star. Steve Saar of the Harvard-Smithsonian Center for Astrophysics and Jim Neff, now at Penn State, used titanium oxide spectral lines to determine that the spots are about 1200 kelvins cooler than the photosphere, which is similar to the difference in temperature between sunspots and the Sun's photosphere.

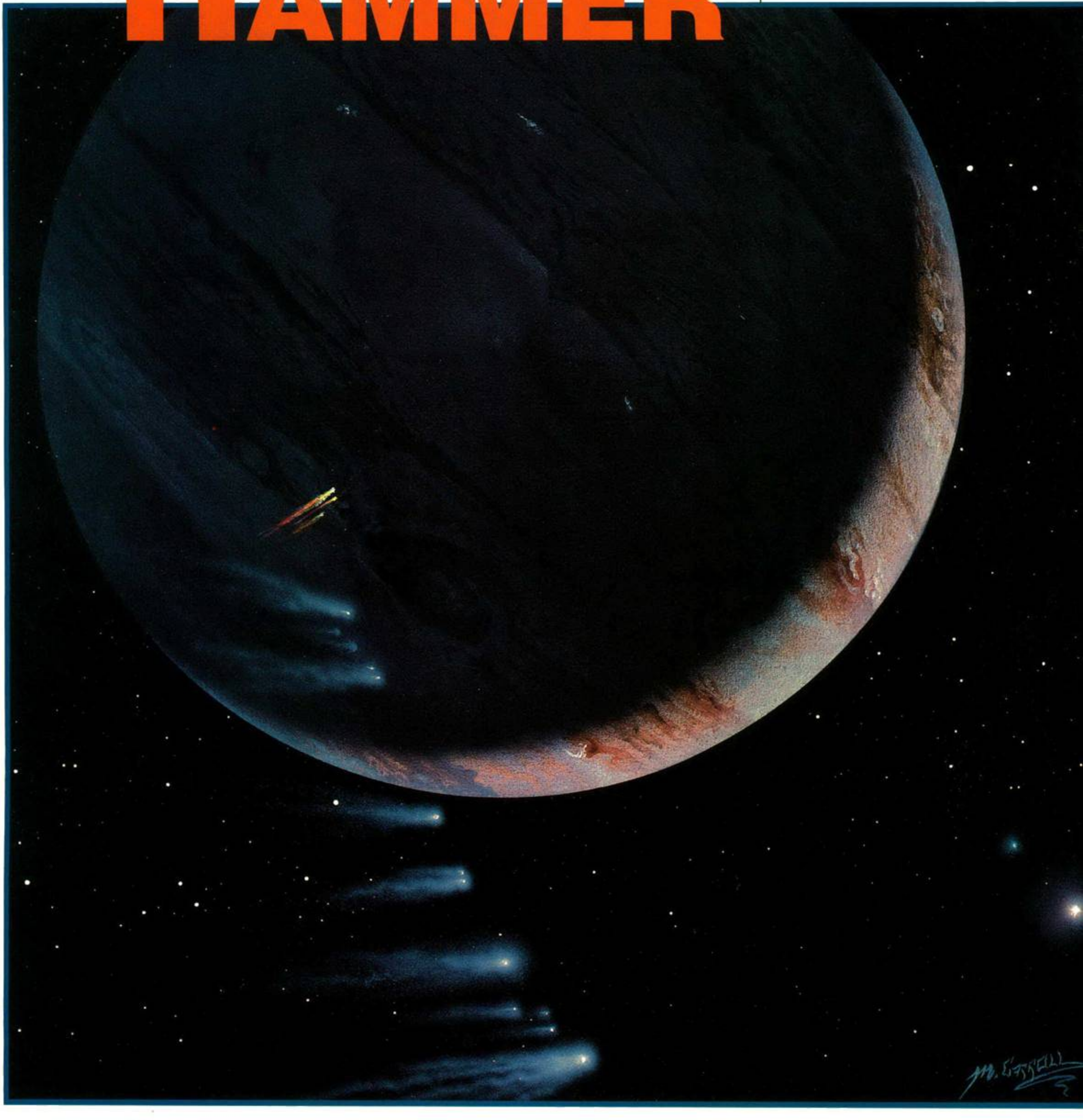
Saar, Nikolai Piskunov of the Astronomical Council in Russia, and Ilkka Tuominen of the University of Helsinki have extended Doppler imaging ideas to magnetic imaging to produce magnetic maps of LQ Hydrae (see opposite). These maps show that the strong magnetic fields lie near, but not exactly in, the low-temperature or spot regions. That suggests the magnetic fields relate more directly to the bright plages, as they do on the Sun, than the dark spots.

Astronomers have quickly moved from developing techniques for mapping stellar surfaces to confirming that what they see are in fact dark spots. They have mapped only about a dozen stars so far, mostly RS CVns and chemically peculiar stars, but are adding more stars all the time. Now researchers need to apply these methods to more solarlike dwarfs in their search to better understand stellar magnetic fields. Overall the tone of stellar astronomy has changed from "I wonder what the surface of a star looks like" to "I wonder what *that* star looks like." □

JOVE'S HAMMER

Next July, Comet Shoemaker-Levy 9 will slam into Jupiter near the latitude of the Great Red Spot.

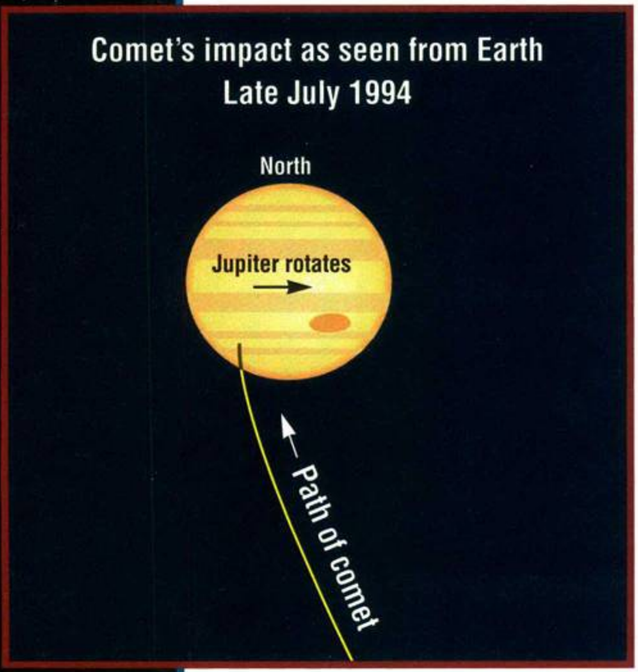
by Robert Burnham



Michael Carroll

Mark your observing calendar now. Next July 20, if astronomers' calculations are correct, you'll see something no one has ever witnessed before: The giant planet Jupiter will be struck by a comet — the ninth Comet Shoemaker-Levy to be precise.

What makes this event especially interesting is that Shoemaker-Levy 9 isn't just one comet but a string of at least 17 (see AstroNews, September 1993). Scientists think that on the comet's last close approach to Jupiter (July 8, 1992 — nine months before its discovery), the planet's immense tidal forces tore the comet's nucleus apart. Each nucleus fragment now constitutes a mini-comet of its own traveling in an orbit that will collide with Jupiter next July. Astronomers aren't sure how big the fragments are, but they estimate that the largest ones run about 10 kilometers in diameter.



JPL/Paul Chodas

In their last hours, the many fragments of Comet Shoemaker-Levy's nucleus will streak northward toward Jupiter at 60 km per second. Five minutes before impact, each will disappear behind the planet as seen from Earth (inset). Expect to see disturbed clouds when the impact sites rotate into view several hours later.

At press time in mid-July, calculations by Donald Yeomans and Paul Chodas of the Jet Propulsion Laboratory indicate the nuclei will hit Jupiter near latitude 45° south. This is about 20° south of the Red Spot's central latitude. With the nuclei forming a "string of pearls" along the comet's original orbit, it'll take roughly one Earth day for all to hit. In that time Jupiter makes almost 2½ rotations, so impact sites will be scattered around the planet in longitude.

What will you see? Much depends on the precise time of impact, which is still uncertain. For an observer at 40° north, Jupiter will rise on the 20th at about 2 p.m. local daylight time, sunset comes around 8:20 p.m., and astronomical twilight ends about 10:15 p.m. Jupiter will set by 12:30 a.m. The comet will shine faintly at 14th magnitude — even in a fully dark sky it will be too dim to spot in your telescope next to bright Jupiter. You will need a CCD camera (and its powerful imaging capability) to photograph it, for the exposure latitude of film is too short.

In any case, the impacts will occur out of sight on Jupiter's nightside hemisphere. While the comet is much too small to "hurt" Jupiter, astronomers expect to see roiling clouds and smears of comet dust when the strike sites rotate into view a few hours after each impact. It's even possible that the impacts may create longer-lived features like the Red Spot. Moreover, if each comet strike creates the bright fireball anticipated (equal to several hundred million megatons of TNT), the flashes could cause the moons on the far side of Jupiter to momentarily brighten.

Planetary scientists' interest in this event is extremely high. Only one meteoritic fireball has been observed at Jupiter (by Voyager 1) and that was tiny. The Hubble Space Telescope will target Jupiter at impact time, as will many researchers worldwide. The impacts will probably dredge up material from deep inside Jupiter and may produce chemical species in its atmosphere that scientists have seldom or never seen.

The Galileo spacecraft, 16 months out from Jupiter, will see the impacts occuring on the limb. Project scientists hope to be able to photograph the strikes, although the craft's tape recorder will be crowded with data from the encounter with the asteroid Ida. Scientists also have some concern that comet debris may linger in Jupiter's vicinity. (Where there are big chunks, multitudes of smaller ones are guaranteed.) But until they observe how the impacting fragments behave, scientists won't know how much danger the spacecraft faces. In any case, after Galileo arrives scientists will be comparing its photos with those of Voyager, looking for fresh craters on the moons.

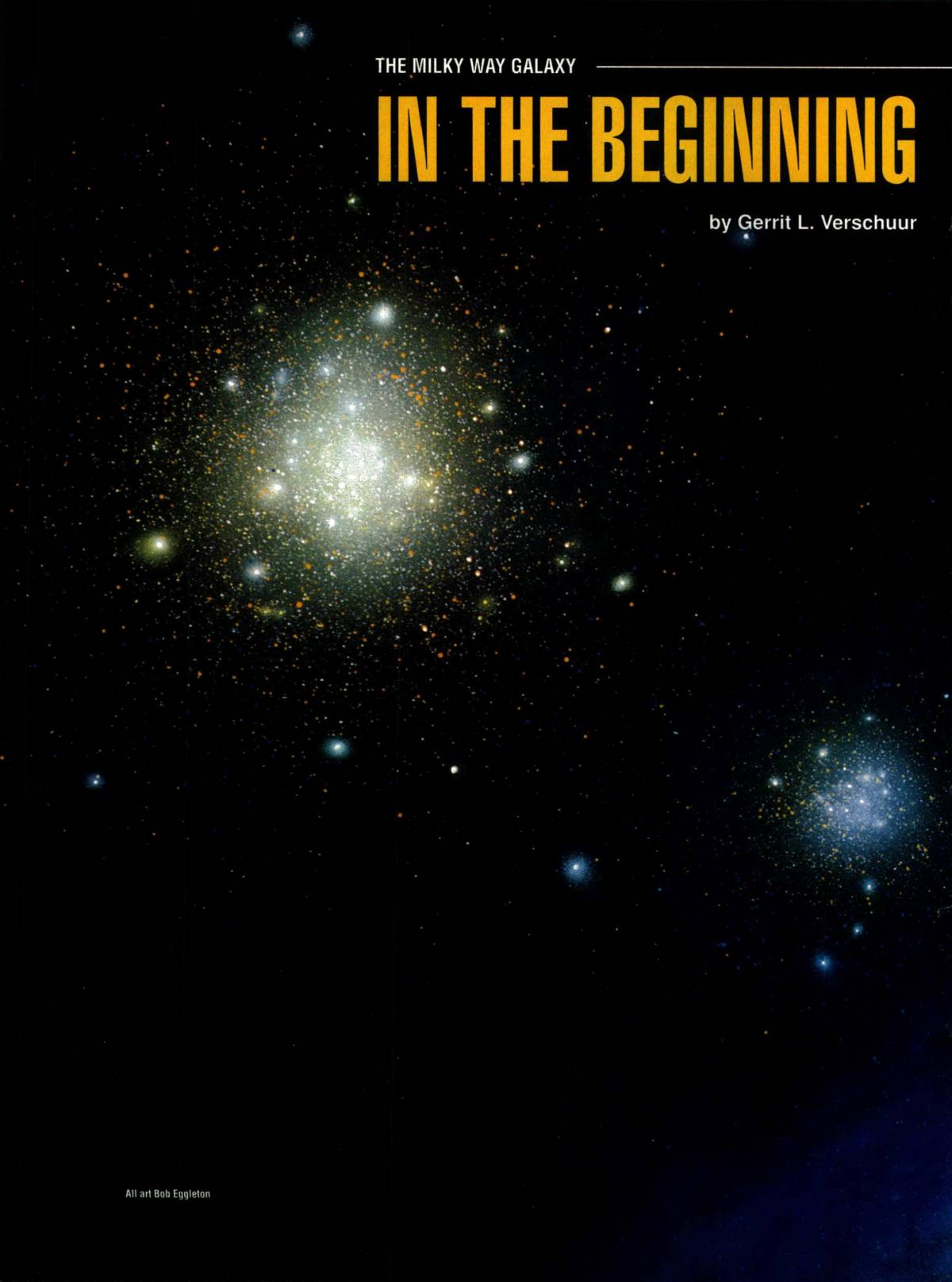
Radio astronomers hope to see major disturbances in Jupiter's magnetosphere (such as aurora) as the impacts eject large quantities of charged particles into the planet's vicinity. Among other things, this will let scientists test whether the enhanced hazes that occasionally form over the Jovian poles come from charged particles.

As scientists refine predictions for this unprecedented event, ASTRONOMY will keep you posted. And look for a complete viewing guide as the event draws near. □

THE MILKY WAY GALAXY

IN THE BEGINNING

by Gerrit L. Verschuur



All art Bob Eggleton

Globular star clusters emerged from clumps of gas as the Milky Way Galaxy took shape. Now the clusters' ancient stars are beginning to offer insights into the earliest days of the Galaxy.

It's a shame no one was there to see it.

Ten billion years ago the Milky Way Galaxy was born out of a giant amorphous cloud of gas. That momentous event led to the births of stars and star clusters. Eventually, it also led to the Sun, planets, and Earth. In the context of the local scheme of the universe, the formation of the Galaxy was everything. And in this Beginning there were globular clusters. Some may even predate the Beginning.

Astronomers are transfixed by beginnings. To know what happened ten billion years ago, how the Galaxy formed and evolved, is to approach questions of our very existence. Why are we here? How did our surroundings get to be like they are? What is to become of us?

The problem with answering such big questions is that the Galaxy formed so long ago. The environments near the Sun, in the Galaxy, and in the universe have all changed dramatically since then. Fortunately, globular star clusters offer some insight into the Galaxy's distant past. Their stars formed simultaneously with the Galaxy — or even a little before — and are relatively unchanged from that distant time. Globular clusters are the Galaxy's time capsules.

But the messages they contain are complex and the methods by which astronomers glean information from them are still rudimentary. Moreover, not all globular cluster researchers agree on basic data like the ages of the clusters. The result is a field in flux that ultimately will answer big questions, but which right now is experiencing its own beginnings.

As astronomer Virginia Trimble of the University of California at Irvine puts it, "There is no neat conclusion from globular cluster data except perhaps that whatever scenario you have in mind for the formation of globular clusters and their significance for galaxies, the truth is probably more complicated."

Big, Fat Globes

Step outside and peer into a telescope on a clear night. Chances are, one of the globular clusters you'll encounter — if you live south of 35° north latitude — is Omega Centauri, the brightest such object in the sky and one of the brighter points of light in the constellation Centaurus. This object glows at magnitude 3.5, bright enough to fool early stargazers into thinking it was a star and designating it as one. However, a look at Omega through even a small telescope instantly reveals it is no solitary star. Instead, Omega appears like a nebulous disk of hazy light studded with hundreds of tiny, pointlike stars. On a night when the air is steady, the three-dimensional nature of the cluster is obvious in a backyard telescope. Omega appears like one big, fat globe of stars.

And it is. Globular clusters like Omega are spheres of stars that float outside the disk part of our Galaxy in

the so-called galactic halo. They are large, the average diameter something like 150 light-years, or 900 trillion miles. About 150 are known in our Galaxy and they're a common feature in other galaxies.

Globulars contain from tens of thousands to more than a million stars, all of which are old and are very poor in heavy elements, which astronomers call metals. The brightest stars in these clusters are red giants. Some binary stars exist within these systems and a small number of these strongly emit X rays. However, the great majority of the stars in globulars are ordinary orange and red dwarfs. Some have evolved off the main sequence and are now slowly cooling cinders working their way toward obscure death. But the rate of nuclear burning in most of a globular cluster's stars is so incredibly slow that these suns will be around, gently glowing, for billions of years to come.

When astronomers study globulars, the first question that comes to mind is, Where did they come from? The answer is largely unknown, but the conventional wisdom among astronomers is that they formed from material that somehow avoided being pulled into the newborn Galaxy's disk.

More than ten billion years ago enormous amounts of mainly hydrogen gas accumulated in our neighborhood and began to contract. Sheets and clumps of material, each of the quadrillions of atoms and molecules attracted by the others' gravity, fell inward to form a giant glowing cloud. Over millions of years the glowing cloud of gas collapsed further. As it did, it began to spin faster. Soon it had become a disk, and within it stars turned on and commenced their lives. The basic construction of the Milky Way Galaxy was over.

According to this scenario, globular clusters are construction debris, leftover clumps of matter that happened to coalesce away from the disk. Many formed simultaneously with the Galaxy's disk, others perhaps before. Because globulars have stood outside the busy, changing disk, they are time capsules that preserve clues to the Galaxy's early days.

Although globulars were born far from the disk's hurly-burly, they don't remain aloof forever. Tied to the Galaxy by gravity's elastic string, they periodically swoop through the disk. Its million stars sparkling, a typical globular cluster slowly orbits the center of the Milky Way in a huge, elliptical loop. Every few tens of millions of years the orbit carries the cluster down through the plane of the Galaxy's disk, where the cluster is swept clean of any gas shed by its stars. By removing material from which new generations of stars could form, the passages through the Galaxy's disk effectively "sterilize" the cluster. Then, several million years later, it passes through the disk again, on the way "up," before heading off on the long part of its orbit away from the Galaxy's disk.

Nature let globular clusters make stars — but only once. Kept as pristine relics of the early Milky Way, they can only look on impotently as the Galaxy evolves and spawns new star-life.

TWIN PLANETS FLOAT on the outskirts of a globular cluster out in the Milky Way's halo. Such clusters hold clues to the Galaxy's past that may let astronomers decipher the earliest days of the Galaxy.

Clues to the Formation of Galaxies

Although globular clusters are easy to see, astronomers' understanding of them has taken over a century to develop. In 1840 the English cleric Thomas Milner described a view of the cluster M13 in Hercules, another of the sky's brightest clusters: "Perhaps no one ever saw it for the first time without uttering a shout of wonder." Writing in the florid style of his time, Milner speculated that the globular nature of the clusters was evidence for the uniting pull of gravity acting on the host of stars within them. "It is striking," he wrote, "to catch a glimpse of a law with which we are so familiar — the law that unites atoms that compose the Earth, forms every raindrop, and moulds the tear that trickles down the cheek of sorrow."

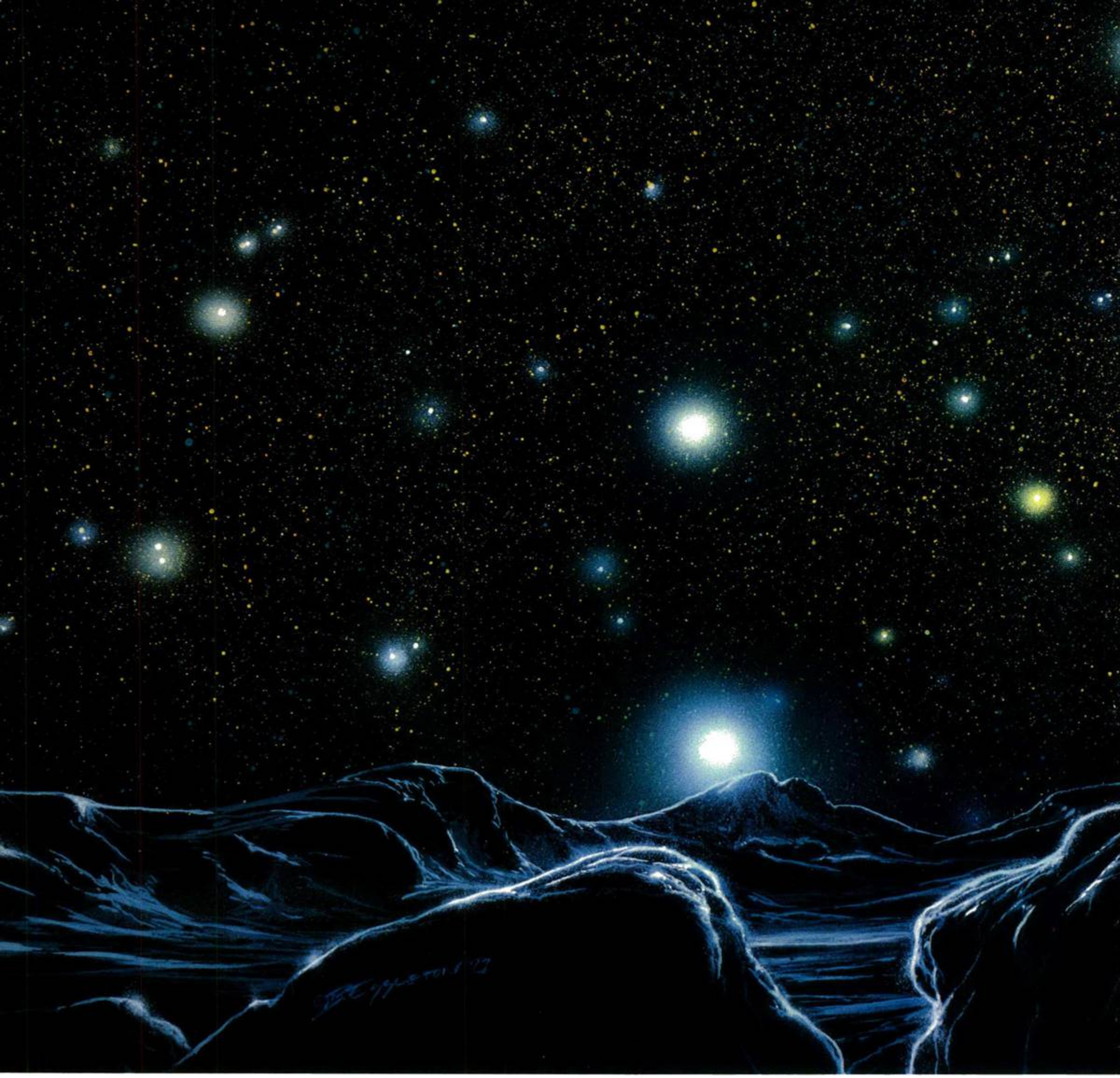
Milner was wrong about what holds raindrops and tears together but right about why both of them fall to Earth. He was deeply impressed that the law of gravity was "in prevailing operation millions of leagues away from our terrestrial residence, binding together in spherical masses whole sidereal systems." In the case of globular clusters, gravity indeed binds stars, holding the cluster stable against disruption even when it passes through the crowded disk of the Milky Way.

But long after astronomers understood the role of gravity, the nature of globular clusters still eluded them. Even as recently as 1927, many astronomers suspected globular clusters were other galaxies, or vice versa. In that year Harlow Shapley of Harvard University took data on globular cluster positions and distances and plotted their locations in three dimensions. Shapley found that globulars scatter through a great spherical region of space centered on the core of the Milky Way. Since Shapley's time astronomers have located globular clusters in swarms around virtually every spiral and elliptical galaxy close enough to reveal its accompanying brood.

Today astronomers know that globular clusters are distributed throughout the Galaxy's halo, a vast sphere of space surrounding the smaller disk. As stars go, the halo is far less populous than the star-rich disk. It contains the Galaxy's globular clusters and a substantial amount of dark matter scattered across a diameter of well over 100,000 light-years.

Although astronomers know the whereabouts of globulars, they do not know the exact story of the clusters' origins or their lives. Globular cluster researcher Richard Larson of Yale University believes globulars are the fossil remains of dwarf galaxies that long ago combined to build the Galaxy. According to Larson, all but the cores of those dwarfs, rich in tightly packed stars, might have been disrupted in the process and continued to exist as globular clusters, whose mostly hydrogen gas broke free and has since diffused throughout the galactic halo. These galaxy cores, then, transformed into globulars.

To understand how to make a galaxy, astronomers need to know about the physical forms of globular clusters. By sorting the clusters, they've found examples that stand out from the rest and sometimes tell them more than all of the ordinary ones. Robert Zinn, a colleague of Larson's at Yale who makes a habit of studying globular clusters, describes Omega Centauri as a "very mysterious object" because it doesn't fit into the neat categories he has devised to describe globular clusters. Zinn has found that globulars exhibit two bloodlines that can be recognized on the basis of their motion, distribution in space, and chemical composition.



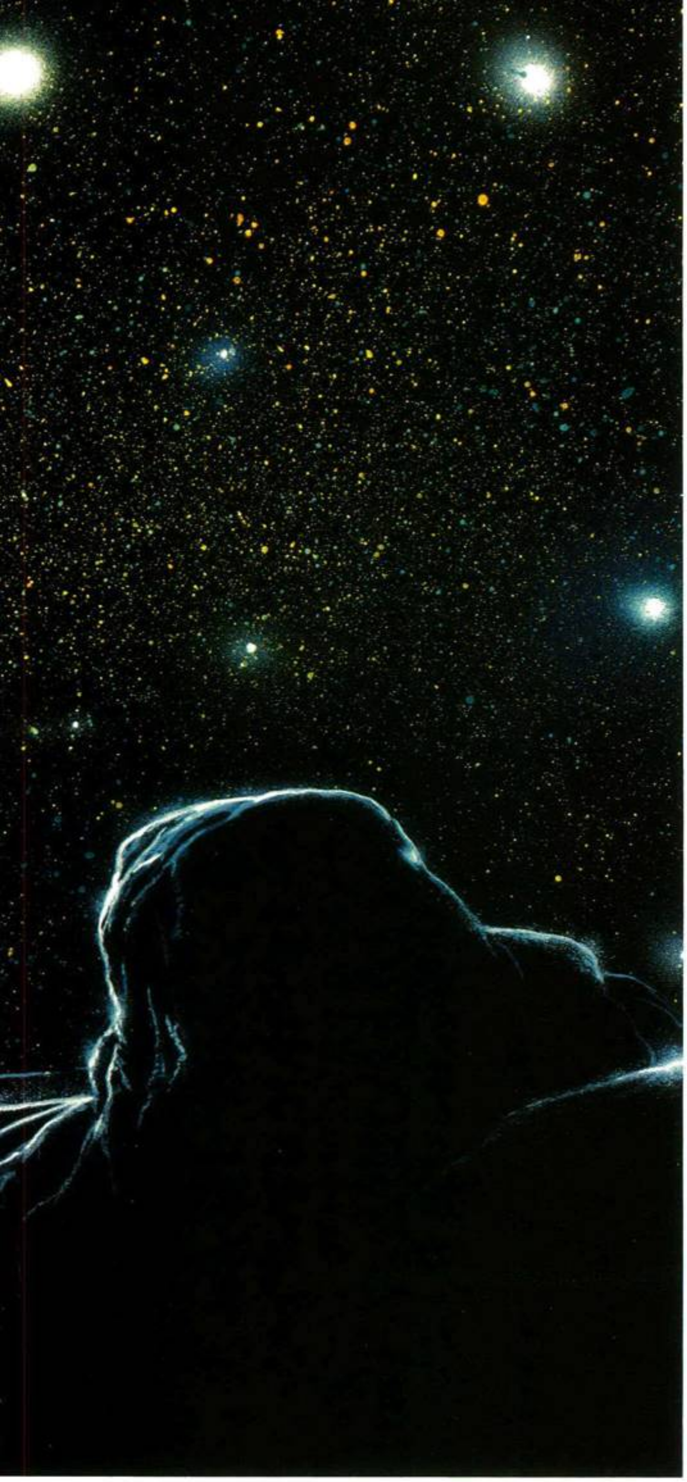
DEEP WITHIN A GLOBULAR CLUSTER, the sky is filled with thousands of dazzlingly bright stars.

One bloodline includes the normal, distant globulars far out in the Galaxy's halo. A second bloodline consists of closer clusters that may have formed in a completely different way.

Of the clusters in the first bloodline, those that wander the outskirts of the halo are as little as 10 billion years old, while those that stay somewhat closer to the galactic center are about 15 billion years old. The most extreme estimates place some clusters at about 17 billion years old.

Clusters belonging to the second bloodline reside much closer to the galactic center, spending their lifetimes within a few thousand light-years of the disk. Their ages are 10 billion years or slightly less which, according to Larson, suggests they may have formed as nearby dwarf galaxies were falling together to help build the skeleton of the Milky Way.

Three-quarters of the clusters in this second bloodline live in the halo of the Milky Way within 90,000 light-years from its center. The age of these clusters relates to the distance at which they orbit. Clusters relatively close to the galactic center seem to be older than those more distant. This leads astronomers to ask, Could aged clusters migrate to the center of the Galaxy? To determine the ages of globular clusters, astronomers look at their chemistry. The oldest stars contain mostly hy-



drogen and helium and relatively little of the heavier metals such as oxygen, carbon, and nitrogen. Each globular cluster has a specific abundance of metals produced at a known rate after the cluster's stars "turn on" and begin fusing hydrogen. Because astronomers know the rate at which stars produce metals, they can determine the age of a cluster by measuring its metal content from a spectrum.

To sum up, then, stars in clusters farthest from the center of the Galaxy probably formed during the original collapse of the gas cloud that eventually built the Milky Way. Stars in clusters closer to the Galaxy, in bloodline two, may have formed as nearby dwarf galaxies moved inward and assembled the disk of the Galaxy.

Omega, the Oddball

Of all the clusters known in the Milky Way, Omega Centauri is a standout because, Zinn says, "It's hard to place it in either group. Omega has the largest known range of metal abundance and may have formed more than one generation of stars." But the cluster could hardly have done that on its own. It's one thing to make a first generation of stars from the gas that was available in the cluster, quite another to build a second generation. That requires abundant and continuing supplies of interstellar matter in the form of gas and dust that will form the new stars. Astronomers are confronted with an age paradox in Omega Centauri. On one hand, they know the cluster has been swept clean of gas and could not have formed successive generations of stars. On the other hand, the cluster contains stars of widely different ages. They are left to ask a peculiar question — could Omega have formed from a long-ago collision of two or more globular clusters?

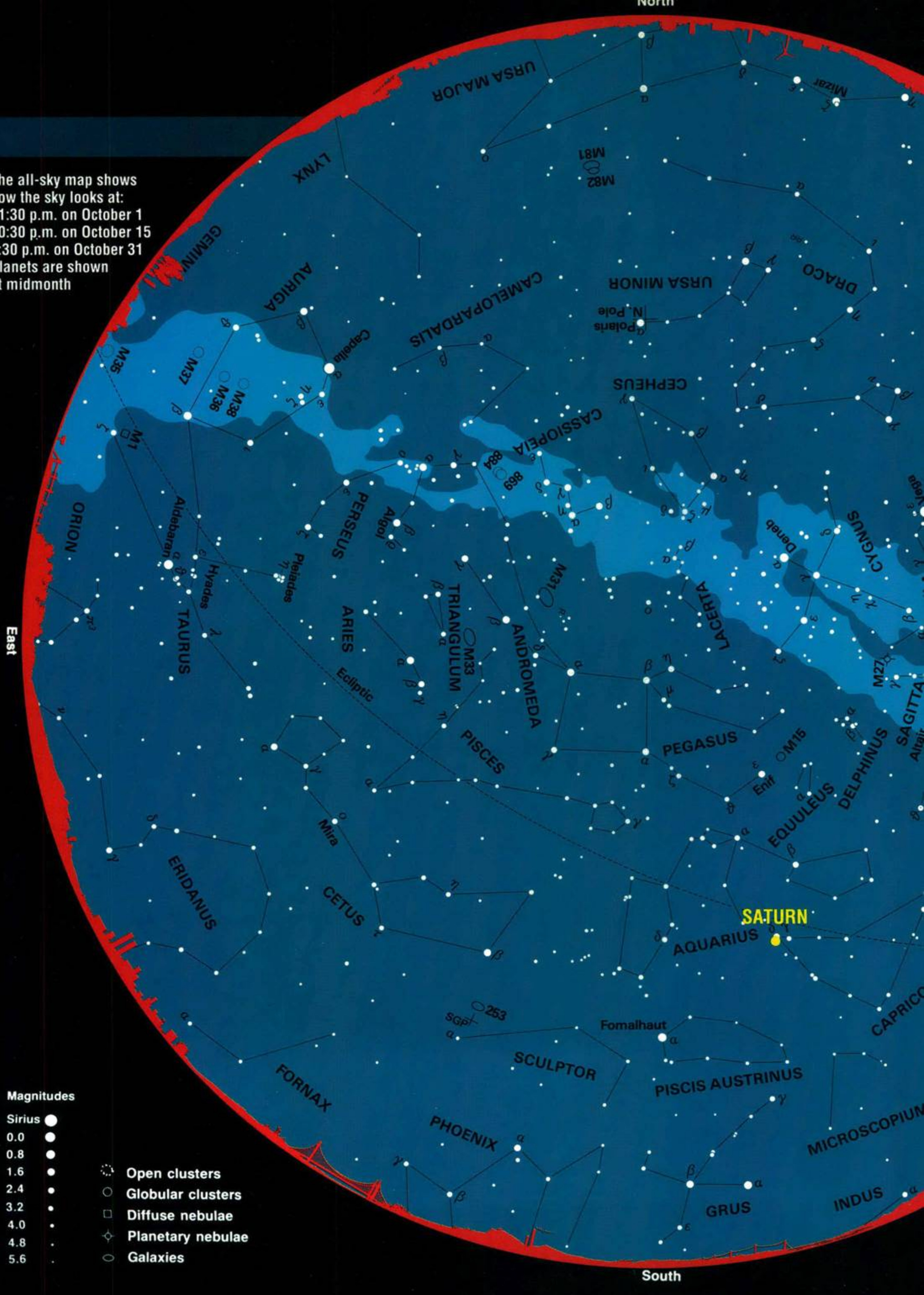
Globular clusters such as Omega Centauri contain mostly red dwarfs living out their middle age with quiet grace. In their youth, the clusters must have had their share of massive stars that long since died violently in supernova explosions. The debris of those blasts would have polluted the space between globular clusters with diffuse matter, adding to what was left from the birth of the original stars. And today red giant stars waft away their outer layers in continual stellar winds, which should add matter to the accumulation of stuff between the stars. Yet in globular clusters this stuff is gone, swept away by repeated encounters with the Galaxy's disk. So in order for Omega Centauri to contain stars of different ages, it must have formed as a collision of two or more smaller clusters, each of which was born at a different time.

In order to go through more than one generation of starbirth, a globular cluster has to be around for a very long time. The fact that astronomers estimate some globular clusters to be as old as 17 billion years, based on their metal content, is significant. (See "The Age Paradox," June 1993.) This poses problems for the big bang theory of the origin of the universe. According to that theory, the universe and all it contains is more like 15 billion years old, give or take a billion or two. Do astronomers understand the origin of the universe? Not yet, at least fully.

Nor do they understand everything they need to about globular clusters. Globular clusters are both among the oldest objects in the Galaxy but also among the least understood. What they can ultimately tell us about how the Galaxy formed and evolved over the past ten billion years is not yet fully known. Fortunately they will be around long enough, in a relatively unchanging state, until our insight and technology allow us to pin down some of the big questions of origins. In fact globular clusters in their glacially evolving lives will be around far after we figure them out — far longer than Earth or the Sun will be around, or humans to watch them. In addition to witnessing the Beginning, globular clusters will see The End. □

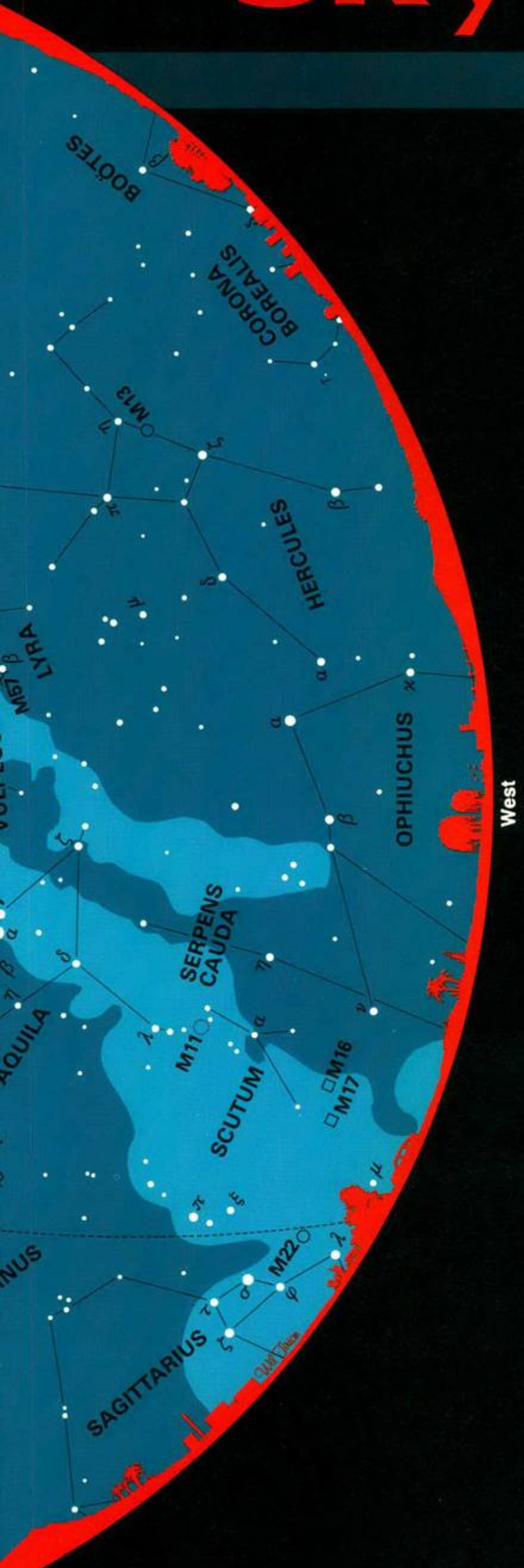
Gerrit L. Verschuur is a research professor of astrophysics at Rhodes College in Memphis, Tennessee. His last article was "Journey into the Galaxy" (January 1993). His thoughts on the future of astronomy appeared in "What's Next for Astronomy" (August 1993).

The all-sky map shows
how the sky looks at:
11:30 p.m. on October 1
10:30 p.m. on October 15
8:30 p.m. on October 31
Planets are shown
at midmonth


North
South
East
URSA MAJOR
Mizar
M81
M82
LYNX
GEMINI
AURIGA
CAMELOPARDALIS
URSA MINOR
Polaris
N. Pole
DRACO
Capella
M35
M37
M36
M38
M1
CEPHEUS
CASSIOPEIA
884
869
ORION
Aldebaran
Hyades
Pleiades
TAURUS
PERSEUS
Algol
TRIANGULUM
M31
M33
ANDROMEDA
ARIES
Ecliptic
PISCES
LACERTA
Deneb
CYGNUS
Vega
M27
SAGITTA
Altair
PEGASUS
M15
Enif
EQUULEUS
DELPHINUS
Mira
CETUS
ERIDANUS
SATURN
AQUARIUS
CAPRICO
SGP
253
Fomalhaut
SCULPTOR
PISCIS AUSTRINUS
FORNAX
PHOENIX
MICROSCOPIU
GRUS
INDUS
Magnitudes
Sirius
0.0
0.8
1.6
2.4
3.2
4.0
4.8
5.6
Open clusters
Globular clusters
Diffuse nebulae
Planetary nebulae
Galaxies

Sky Almanac

October 1993



Map Art by Wil Tirion

ORIONIDS PEAK ON OCTOBER 21

Although Comet Halley has receded into the depths of the solar system, this month tiny bits of debris from the famous comet will plow into Earth's atmosphere and burn up. You can best see the resulting streaks of light, the Orionid meteor shower, from a dark location on the mornings of October 21 and 22.

SATURN BRIGHT IN THE EVENING

Saturn stands out in the evening sky this month, the only bright planet you'll see until Venus rises in the wee hours. You can find the ringed planet high in the south at mid-evening among the background stars of Capricornus.

CERES AT BEST VISIBILITY

This month you can easily view the largest asteroid, 1 Ceres, with binoculars or a small telescope. Ceres comes to opposition on October 22, when the 7th-magnitude point of light lies in Cetus.

URANUS AND NEPTUNE TOGETHER

This is your last chance to view Uranus and Neptune so close together. The two outer planets lie 1.1° apart this month, easily fitting into the same low-power field of view, but they are separating slowly and won't be as close again for 172 years.

Calendar of Events

6 Mercury passes 2° south of Mars, 1 p.m. EDT

7 Asteroid Parthenope is at opposition

8 Last Quarter Moon is at 3:35 p.m. EDT
Draconid meteor shower peaks

13 The Moon passes 7° south of Venus, 9 p.m. EDT
Mercury is at greatest eastern elongation (25°)

14 The Moon is at perigee (221,980 miles from Earth), 9:48 p.m. EDT

15 New Moon is at 7:36 a.m. EDT

16 The Moon passes 1.7° south of Mars, 6 p.m. EDT

17 The Moon passes 1.7° north of Mercury, 1 a.m. EDT

18 Jupiter is in conjunction with the Sun

21 Orionid meteor shower peaks

22 First Quarter Moon is at 4:52 a.m. EDT
Ceres is at opposition

24 The Moon passes 7° north of Saturn, 9 a.m. EDT

27 The Moon is at apogee (252,341 miles from Earth), 7:56 p.m. EDT

28 Mercury passes 2° south of Mars, 2 a.m. EDT
Saturn is stationary

30 Full Moon is at 8:38 a.m. EDT

Eye on the Sky

by Deborah Byrd

METEORS FROM THE HUNTER

STREAKS OF LIGHT will pepper the sky on the mornings of October 21 and 22, as the Orionid meteor shower reaches its peak. The meteors are specks of dust from Comet Halley burning up in our atmosphere.

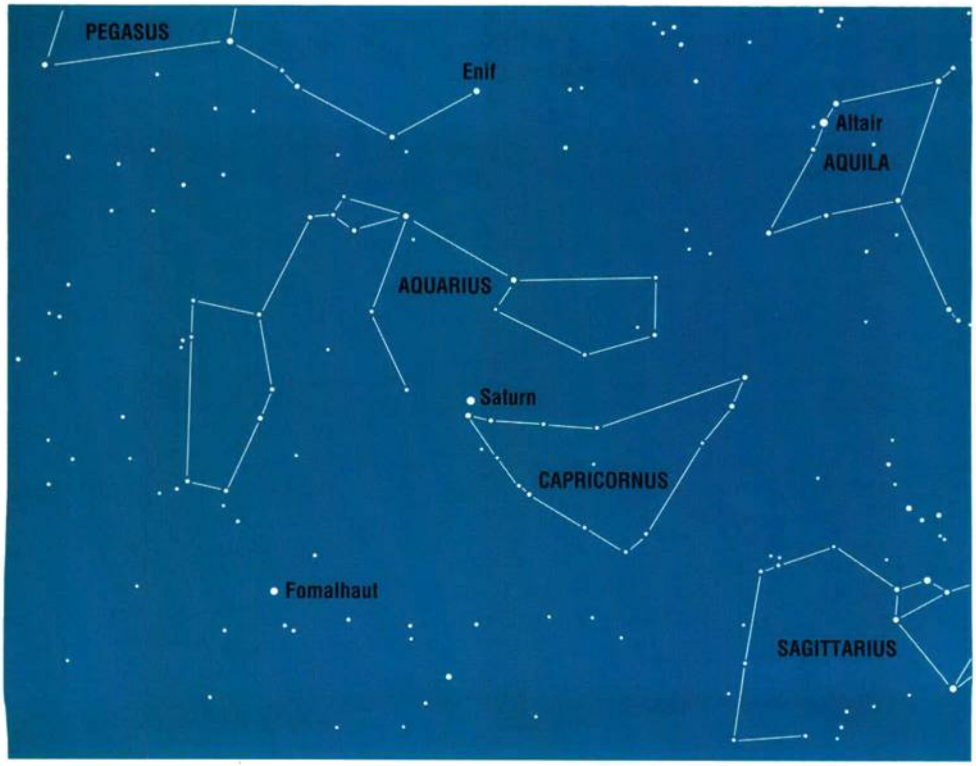
For observers in the United States and Canada, the Orionid meteor shower this year peaks on the evening of October 21. The best time to watch the meteor shower is in the hours after midnight, when Earth's night side is rushing headlong into the meteors, so you should try to view the Orionids either on the morning of October 21 or 22. The Moon won't be casting any unwanted light into the sky then either, because it sets around midnight. If you avoid earthly lights, you should see a couple of dozen meteors per hour streaking across the night sky.

Orionid meteors fascinate us in part because they are small fragments of the most celebrated comet, Comet Halley. Comets often are described as "dirty snowballs," and they seem to be loosely packed snowballs at that. As sunlight warms a comet's nucleus, the ice sublimates and carries off bits of dust with it. This cometary debris forms what is called a meteor stream, which you can imagine as a sort of river of dusty particles orbiting the Sun. Whenever Earth has to ford one of these streams in the course of its own orbit around the Sun, bits of the debris enter our atmosphere at high speed and vaporize from friction with the air. We see the streaks of light left behind as meteors.

Meteors from a given shower appear to enter our sky at a point called the radiant. Actually, the meteors strike the atmosphere on parallel paths; the radiant is an illusion. It's the same type of illusion that causes railroad tracks to appear to converge in the distance.

Many people mistakenly believe that they should stare directly at a shower's radiant to see the most meteors. In fact, most meteors don't become visible until they are 30° or so from the radiant. To find the shower's radiant, you need to project the meteors' paths backward in the sky. Try plotting the paths of the meteors you see relative to the star background. (The circular map that opens Sky Almanac in the January issue matches October's early morning sky.) You'll find that the meteors do indeed seem to spring from one spot in the sky.

SATURN DOMINATES the view to the south at mid-evening this autumn, outshining any star in the surrounding constellations.



A meteor shower takes its name from its radiant. The Orionids appear to radiate from the upraised arm of the constellation Orion the Hunter. Orion rises before midnight and lies high in the south before dawn on the night the shower peaks. Just remember that the meteors will appear in all parts of the sky. All you have to do is dress warmly, recline comfortably, and look up.

A BRIGHT EVENING PLANET

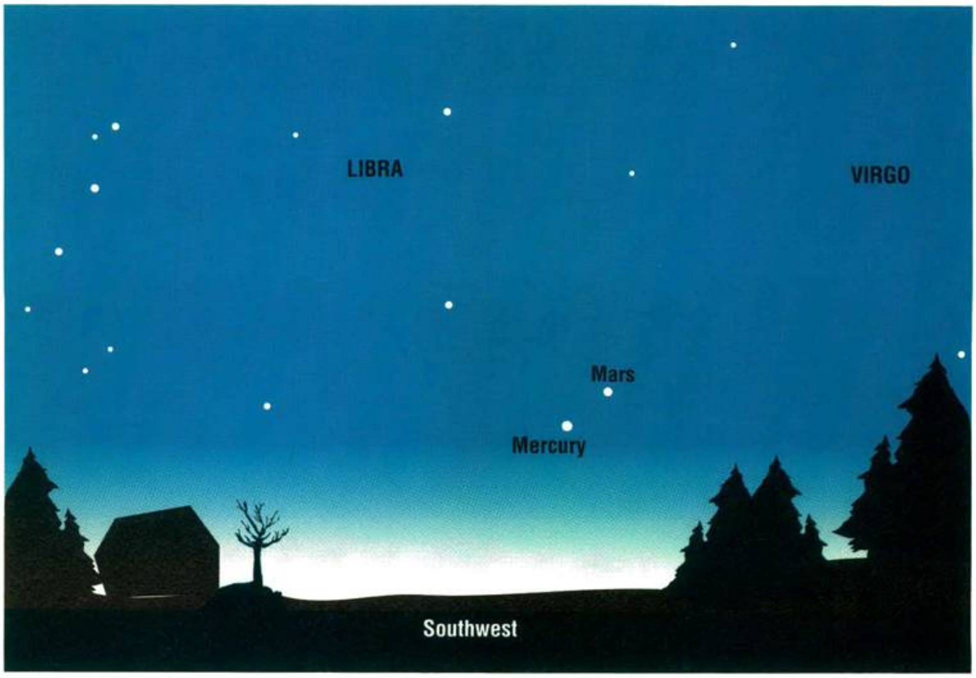
Saturn is now the only bright planet visible throughout the evening. It lies well up in the southeast at sunset and doesn't sink below the western horizon until after midnight. Earth passed between this planet and the Sun in August and since then — as the distance between our two worlds has increased — Saturn has been growing slightly dimmer. This month it shines at magnitude 0.6.

Saturn lies near the arrowhead asterism of the constellation

Capricornus the Sea Goat. The 3rd-magnitude star near the planet is Deneb Algedi, the tip of the arrow and the brightest star in Capricornus. The star and planet lie just over a degree apart.

This month Saturn barely moves relative to the sky background, and on October 28 it is actually stationary. To understand why, imagine riding in a car as it passes a slower car on the highway. If you focus on the other car, you can trick yourself into believing that it is moving backward against the distant landscape. In the same way, the outer planets usually appear to move eastward, or prograde, against the background stars. But for some weeks or months around the time we pass between them and the Sun, they appear to move toward the west, or retrograde. Planets move most slowly in the sky around the time they switch from prograde to retrograde motion, or back again. At the stationary point they appear to poise motionless — as though holding their breath — before seeming to change direction. Because Saturn switches from prograde to retrograde motion this month, it moves slowly against the background stars.

The end of Saturn's retrograde motion signals that the best time of year to observe this planet is drawing to a close. It will appear for fewer hours of the night during the coming months, so take this opportunity to enjoy the planet's steady light and golden color before it vanishes into evening twilight this winter.



SPOT MERCURY AND MARS together during the first week of October. The pair lie 2° apart on the 6th, when they are 5° above the west-southwestern horizon 20 minutes after sunset.

HUNTING FOR THE MOON

As I mentioned last month, the Full Moon nearest the autumnal equinox is called the Harvest Moon. The following Full Moon, which comes this year on October 30, is called the Hunter's Moon. Both the Harvest Moon and the Hunter's Moon rise shortly after sunset for several evenings after the night of the Full Moon. On each of these evenings, the Moon looks Full or nearly Full. In years past, the Harvest Moon helped farmers to see as they worked late in the fields, bringing in their crops. The Hunter's Moon then helped those hunting game in the newly cleared fields. This year the light of the Hunter's Moon will illuminate the paths of children hunting candy for Halloween.

OCTOBER'S PLANETS

As October begins, **Mercury** lies in the west-southwestern sky after sunset. But that doesn't mean you'll see it easily. Mercury's current apparition is unfavorable because at this time of year the ecliptic — the path of the Sun, Moon, and planets across the sky — slants low with respect to the evening horizon.

Your best hope for spotting Mercury comes on October 6, when the innermost planet lies 2° due south of **Mars**. You'll need clear skies and an unobstructed horizon to see the pair; try binoculars if you can't locate them with your naked eye. Mercury is the brighter of the two planets, shining at magnitude –0.1 compared with Mars at magnitude 1.6.

After the planets' conjunction, Mercury moves toward its greatest separation from the Sun — called greatest elongation — on October 13/14. Unfortunately, it is then no higher in the sky than earlier in the month. Mars, on the other hand, sinks slowly into the Sun's glare. It disappears from view late this month, returning to the morning sky early next year.

After darkness falls and Mercury and Mars have set, look toward the southeast. You'll see **Saturn** about 30° high, one-third of the way from the horizon to the zenith. Hours will pass before any other planets appear over the eastern horizon. Finally **Venus** comes up about two hours before the Sun. This planet is also getting closer to the Sun's glare, but is so bright at magnitude –3.9 that you can follow it deep into twilight.

Jupiter disappears into the Sun's glare during the first week of October and reaches conjunction with our star on the 18th. It will return to the predawn sky in early November.

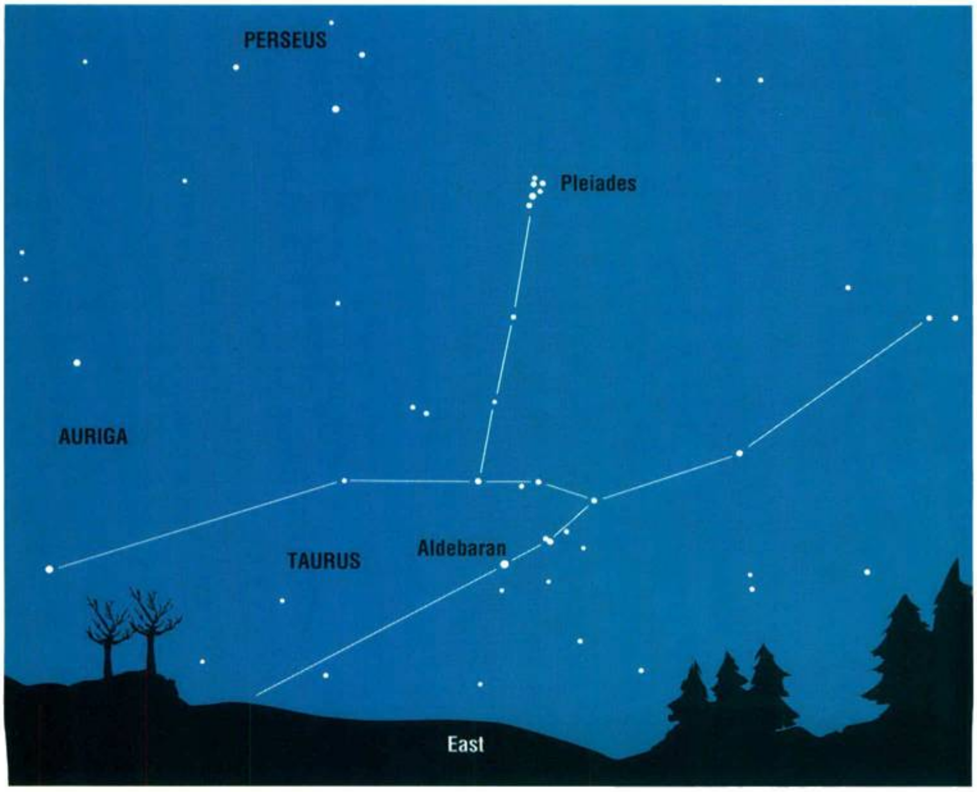
THE STARRY SKY

At this time of year, the famed Pleiades, or Seven Sisters, rise in the east as darkness falls. The Pleiades is an open star cluster, a group of a few hundred stars born from a single cloud of gas and dust. It's easy to recognize with the naked eye, looking like a tiny dipper of stars.

I have many wonderful memories of observing the Pleiades, but my favorite comes from the night I showed the cluster to my daughter, then age 6. When I told her they represented seven sisters, she at once said, "But there are only six stars!" She's not alone; most people with their naked eye see only six stars in the Pleiades.

What happened to the seventh sister, the "lost Pleiad?" One legend says that Merope — who along with Alcyone, Asterope, Celaeno, Electra, Maia, and Taygeta were the seven daughters of Atlas and Pleione — married a mortal and was so ashamed that she hid her face. Another declares that Electra, who descended from the sky to help save Troy from the Greeks, became too anguished when the city fell to return to her celestial sisters.

THE PLEIADES RETURNS to the evening sky in October, rising in the east as darkness descends. Most people can spot six stars in this cluster with their naked eye.



Probably because it is so prominent in late fall and winter, when days are short and nights long, the Pleiades is often associated with death. Rituals honoring the dead have long been centered around mid-November, when the cluster is highest in the sky at midnight.

For people south of Earth's equator, the Pleiades is also high in the sky around midnight this time of year. But to them, this cluster shines down on a part of Earth where it is late spring. So it's no surprise that people in the Southern Hemisphere have always associated the Pleiades with light, warmth, and rebirth. □

Deborah Byrd writes and produces the daily "Earth and Sky" radio series. It now can be heard on over 440 stations.

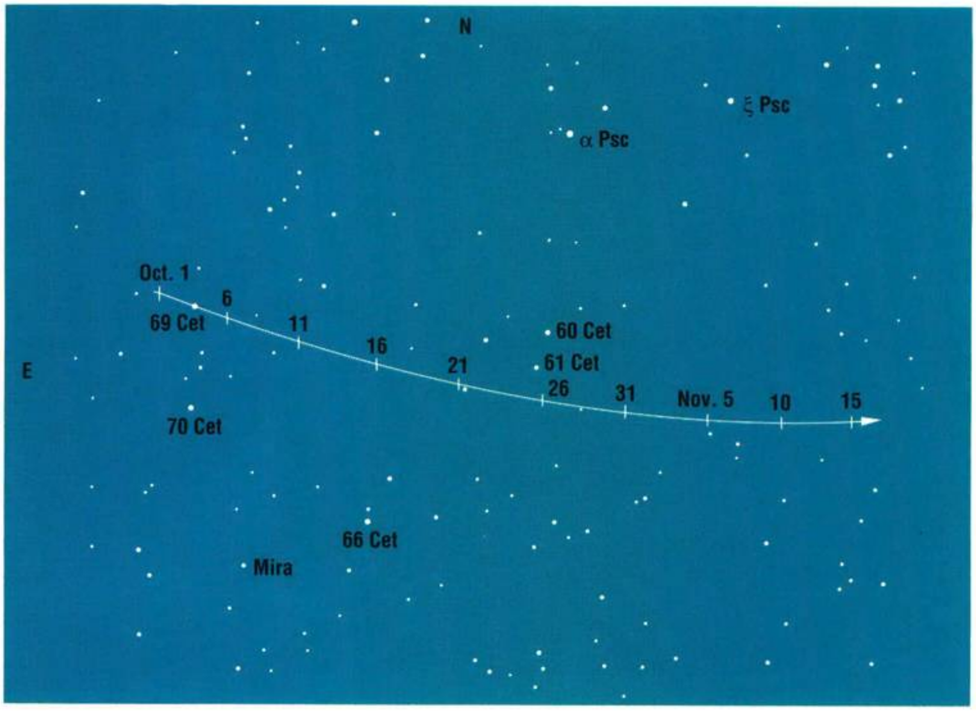
Through the Eyepiece *by Rick Shaffer*

CERES SHINES BRIGHTLY AT OPPOSITION

With over 5,000 asteroids now having names, you might think it strange to highlight just one of them. But 1 Ceres is far from a common member of this enormous group. At 1,000 kilometers in diameter, Ceres is nearly twice as big as runnerup 2 Pallas, and it is the second-brightest asteroid after 4 Vesta. Ceres is perfectly placed for observing this month, reaching opposition on October 22 in northern Cetus.

The Italian astronomer Giuseppe Piazzi discovered Ceres on January 1, 1801, when he noted its telltale motion against the background stars. You can repeat Piazzi's observations any time this month with the help of the map at right. Throughout October and the first half of November, Ceres shines brighter than 8th magnitude, bringing it within easy range of binoculars or a small telescope. (At opposition on the 22nd, it glows at magnitude 7.4.) The map shows stars to magnitude 8.5, so you should have little trouble spotting Ceres once you locate the starfield. To follow in Piazzi's footsteps, however, you'll have to check the field again a night or two later to confirm the asteroid's motion against the stellar backdrop.

To further aid your search, Ceres passes close to several bright stars during the course of the month. On October 4, the asteroid passes less than 0.1° north of the 5th-magnitude star 69 Ceti. Later that same week, Ceres passes 3° north of Mira, the most famous long-period variable star in the sky. Mira (Omicron Ceti) is now about four months past maximum brightness, so it should glow at 7th magnitude and show a distinct ruddy hue in your telescope. And on October 26, Ceres passes 0.4° south of 6th-magnitude 61 Ceti. After that Ceres starts to grow dimmer, but with a little effort you should have no problem viewing the first asteroid through the rest of this autumn.



LOCATE ASTEROID 1 CERES, which peaks at magnitude 7.4 at opposition this month, as it traverses northern Cetus. Positions are shown for 11 p.m. EDT (10 p.m. CDT, 9 p.m. MDT, and 8 p.m. PDT).

COORDINATES FOR CERES

Date	R.A. (2000)	Dec.
Oct. 1	2h23.8m	0°37'
Oct. 6	2h20.4m	0°18'
Oct. 11	2h16.5m	–0°00'
Oct. 16	2h12.3m	–0°17'
Oct. 21	2h08.0m	–0°32'
Oct. 26	2h03.5m	–0°45'
Oct. 31	1h59.1m	–0°54'
Nov. 5	1h54.8m	–1°00'
Nov. 10	1h50.7m	–1°02'
Nov. 15	1h47.0m	–1°00'

SATURN'S STABLE OF SATELLITES

Aside from Ceres, October might at first seem like a slow month for observing. The rich summer skies have given way to the sparse fall skies and many of the bright planets are lost in the Sun's glare.

But any month that features Saturn conveniently located in the evening sky is anything but boring! The ringed planet lies high in the south at midevening and doesn't set until well after midnight. You can find it easily as the bright object in northern Capricornus.

In a telescope, you can see a wealth of subtle detail in Saturn's cloudtops and in the planet's glorious ring system. But those details were easiest to see around opposition last August, when the planet presented its largest disk. This month I want to concentrate on the ringed planet's often forgotten system of satellites.

Saturn's system includes no less than 18 major satellites, and that's not counting the innumerable small chunks of debris, or "mini-satellites," that make up the planets' rings. However, only five of Saturn's entourage are easy to see in backyard telescopes.

Titan is the flagship. It's a world unto itself, the only satellite in the solar system with a significant atmosphere. Titan measures 5,150 kilometers in diameter, making it the second largest satellite in the solar system, after Jupiter's Ganymede. And it reflects a lot of light in our direction, so it shines brightly at magnitude 8.3. It also lies well away from the glare of Saturn: The distance from the center of Saturn to Titan's orbit is over four times the diameter of the planet's rings. Titan is bright enough and far enough from Saturn that you should have no trouble seeing it in the eyepiece. In fact, you can often spot Titan with no more than binoculars.

Titan and the other bright Saturnian satellites orbit nearly in the plane of the rings. With the rings now tilted just 13° to our line of sight, the satellites don't pass far north or south of the planet's disk. They are easiest to see when they are as far as possible east or west from Saturn, when near greatest eastern or western elongation.

Significantly closer to the rings than Titan is Rhea, the second brightest of Saturn's satellites. The 1,530-kilometer-diameter chunk of rock and ice shines at magnitude 9.7. Rhea lies about twice the apparent diameter of Saturn's rings from the center of the planet, so it stands out quite prominently when near one of its elongations.

The next bright satellite in from Rhea is Dione, which lies about 1.5 times the rings' diameter from the center of Saturn. It reflects about the same percentage of sunlight hitting it as Rhea does, but because it has a smaller diameter of 1,120 kilometers it appears slightly fainter, at magnitude 10.4.

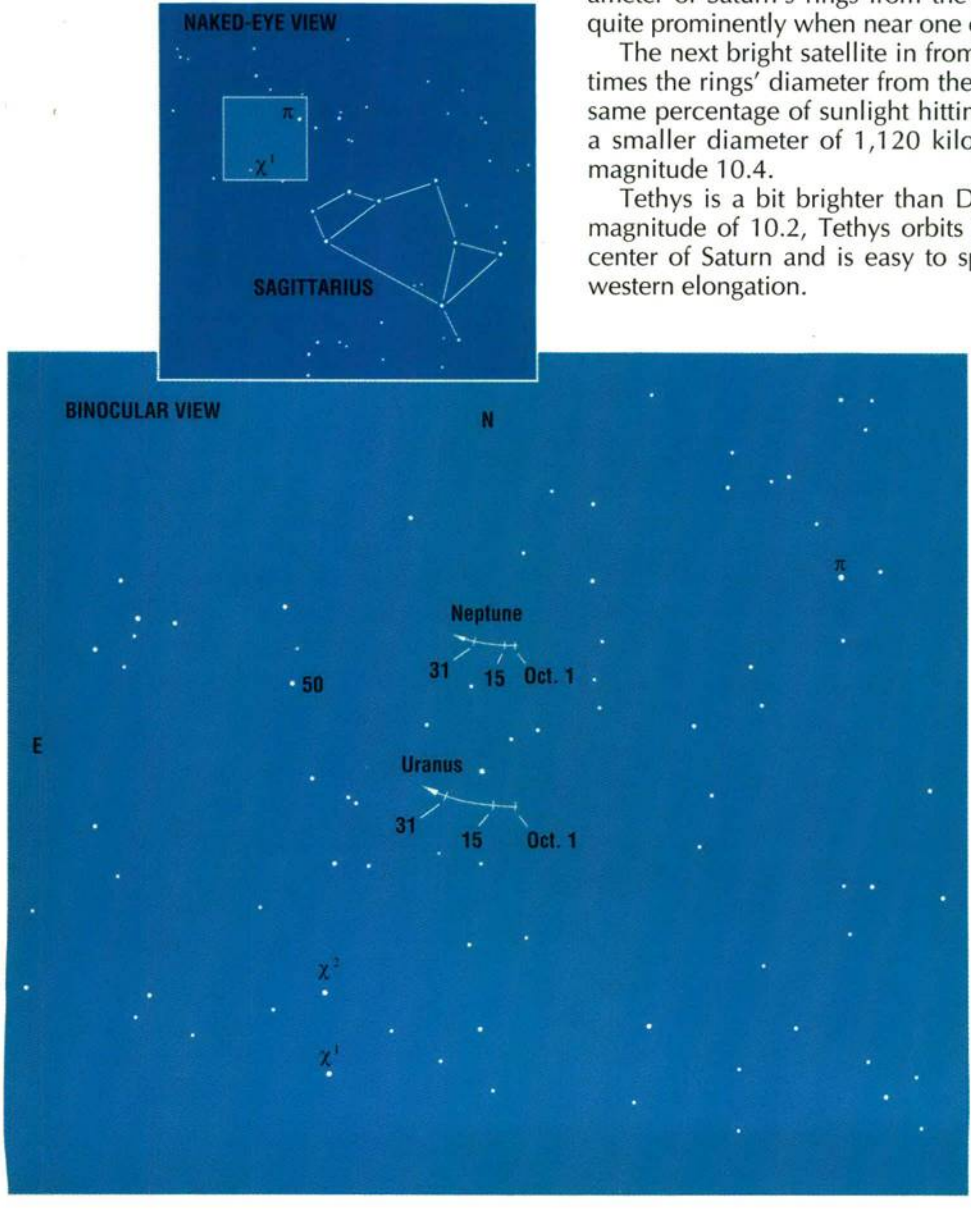
Tethys is a bit brighter than Dione but no easier to see. Despite a magnitude of 10.2, Tethys orbits just over one ring diameter from the center of Saturn and is easy to spot only when it lies near eastern or western elongation.

You can find Titan, Rhea, Dione, and Tethys with the help of the chart on the opposite page. The chart shows the positions of those four satellites relative to Saturn during the evening hours around the time of New Moon. South is at top and east to the right in the diagrams, matching the view you would see in an inverting telescope.

But that makes only four satellites, and I promised you five. The final one is Iapetus, at 1,460 kilometers in diameter the third largest of Saturn's satellites. I didn't mention it earlier because its orbit is much larger than the others, which sometimes makes it difficult to pick out from the background.

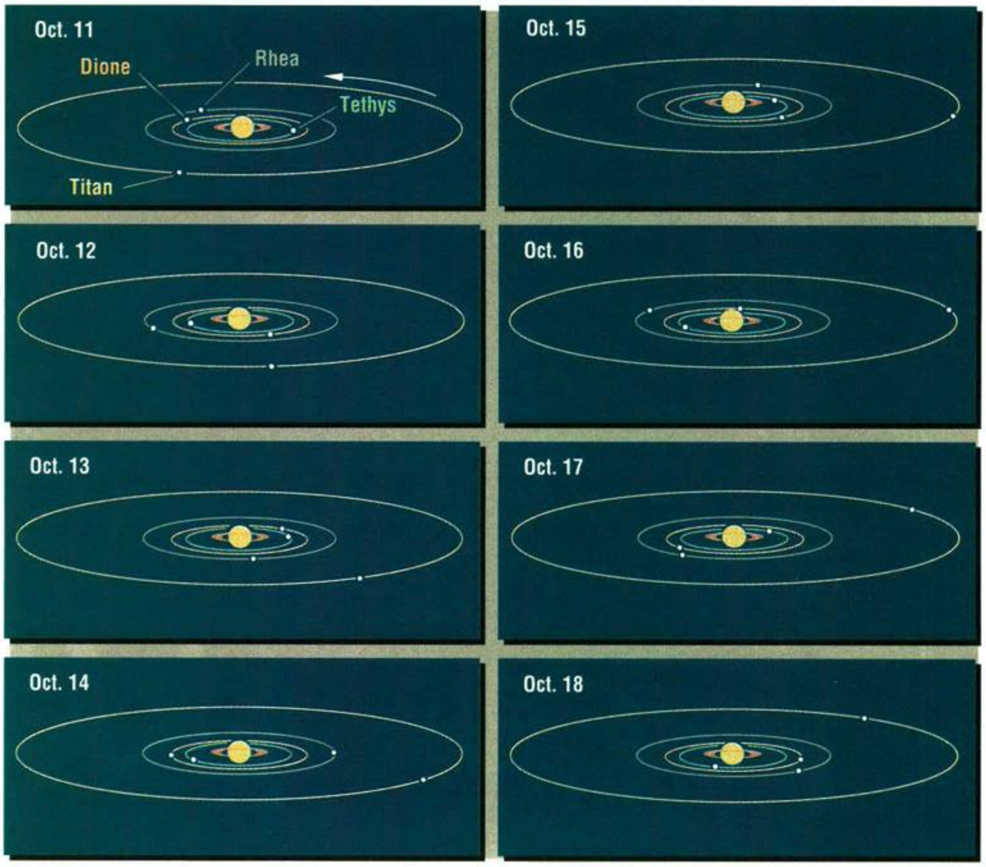
What makes Iapetus intriguing is that it brightens and fades as it orbits Saturn. It's brightest, at magnitude 10.1, when it lies due west of Saturn. By the time it reaches eastern elongation about 40 days later, it has faded to magnitude 11.9. That's a difference of 1.8 magnitudes, or a factor of five in brightness. What's happening?

URANUS AND NEPTUNE are together again throughout October, lying just 1.1° apart in northeastern Sagittarius. Positions are shown for 11 p.m. EDT (10 p.m. CDT, 9 p.m. MDT, and 8 p.m. PDT).



Iapetus has a bright side and a dark side. And like our Moon, Iapetus rotates once on its axis in the time it orbits Saturn once, so it always turns the same face toward the planet. Its bright side happens to face us when it's west of Saturn and faces away when it's to the east.

Iapetus reaches western elongation on September 18, so that's your best chance to spot the elusive satellite. On October 7, it lies due north of Saturn, and on the 26th, it is farthest east of Saturn and at its dimmest. Iapetus doesn't return to western elongation again until December 6.



SATURN'S FOUR BRIGHT SATELLITES, ranging from 8th to 10th magnitude, put on a show during the dark of the Moon this month. Positions are shown for 11 p.m. EDT (10 p.m. CDT, 9 p.m. MDT, and 8 p.m. PDT), with south at top and east to the right.

TELESCOPIC PLANETS

After Saturn, the bright planets offer slim pickings for telescopic observers. **Mercury** makes an evening apparition during the first half of October, reaching greatest eastern elongation (25°) on October 13/14. Because the ecliptic — the apparent path of the Sun, Moon, and planets across the sky — makes such a shallow angle with the western horizon on fall evenings, Mercury stays near the horizon. Even with clear, steady skies, don't expect to see more than a shimmering, gibbous disk in your eyepiece.

If you rise early, **Venus** makes a worthwhile though not spectacular target low in the east before dawn. When you turn your telescope on Venus, you'll see an 11"-diameter disk that is slightly over 90 percent lit.

Mars and **Jupiter** are about as easy to spot as Mercury. Both lie very low in the west-southwest just after sunset early in the month. The haze and poor seeing near the horizon almost guarantee that you won't get a good look at these two worlds until they return to the morning sky — next month for Jupiter and early 1994 for Mars.

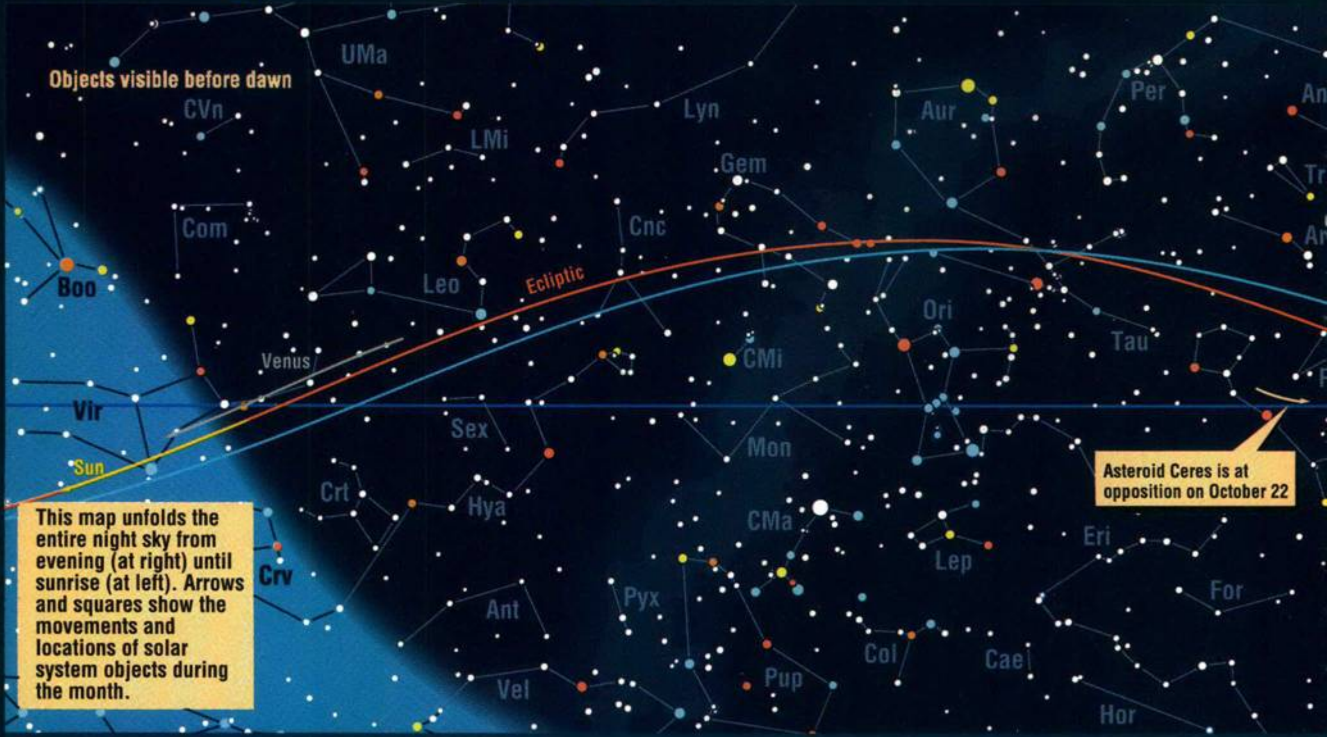
DON'T OVERLOOK URANUS AND NEPTUNE

Luckily two fainter planets make up for the lack of bright planets this month. Uranus and Neptune are well placed in the south shortly after darkness falls. This is the last month you can see the two worlds so close together. They were nearly in conjunction in late September, when they came within 0.1" of each other in right ascension, but appear slightly closer together in October.

You can find them about 1.1° apart in northeastern Sagittarius (see the finder charts on the opposite page). Uranus appears as a blue-green dot shining at magnitude 5.7, while Neptune is more blue-gray and glows at magnitude 7.9. Don't miss this opportunity to see them together in a single, low-power field of view — they won't be as close again for another 172 years! ☐

Rick Shaffer is an engineer in the aerospace industry and a freelance writer living in Altadena, California.

The Solar System October 1993


Objects visible before dawn
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Ecliptic
Ori
Tau
Venus
CMi
Vir
Sex
Mon
Sun
Crt
Hya
CMa
Eri
Crv
Lep
For
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Pyx
Col
Cae
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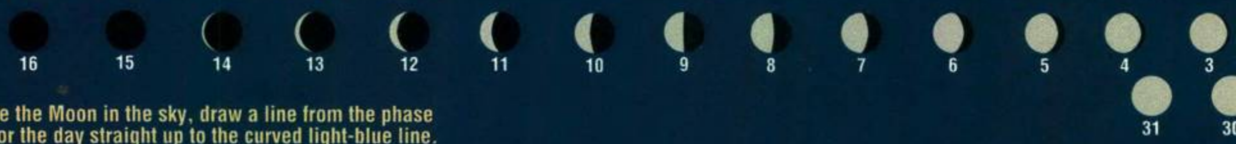
This map unfolds the entire night sky from evening (at right) until sunrise (at left). Arrows and squares show the movements and locations of solar system objects during the month.

Asteroid Ceres is at opposition on October 22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To locate the Moon in the sky, draw a line from the phase shown for the day straight up to the curved light-blue line.

10"

S

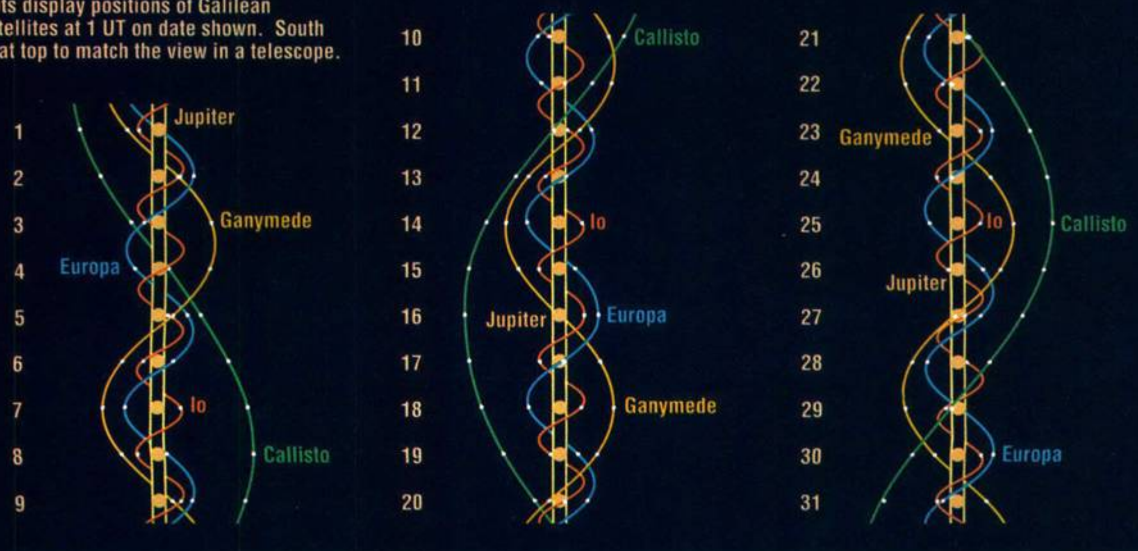
W E

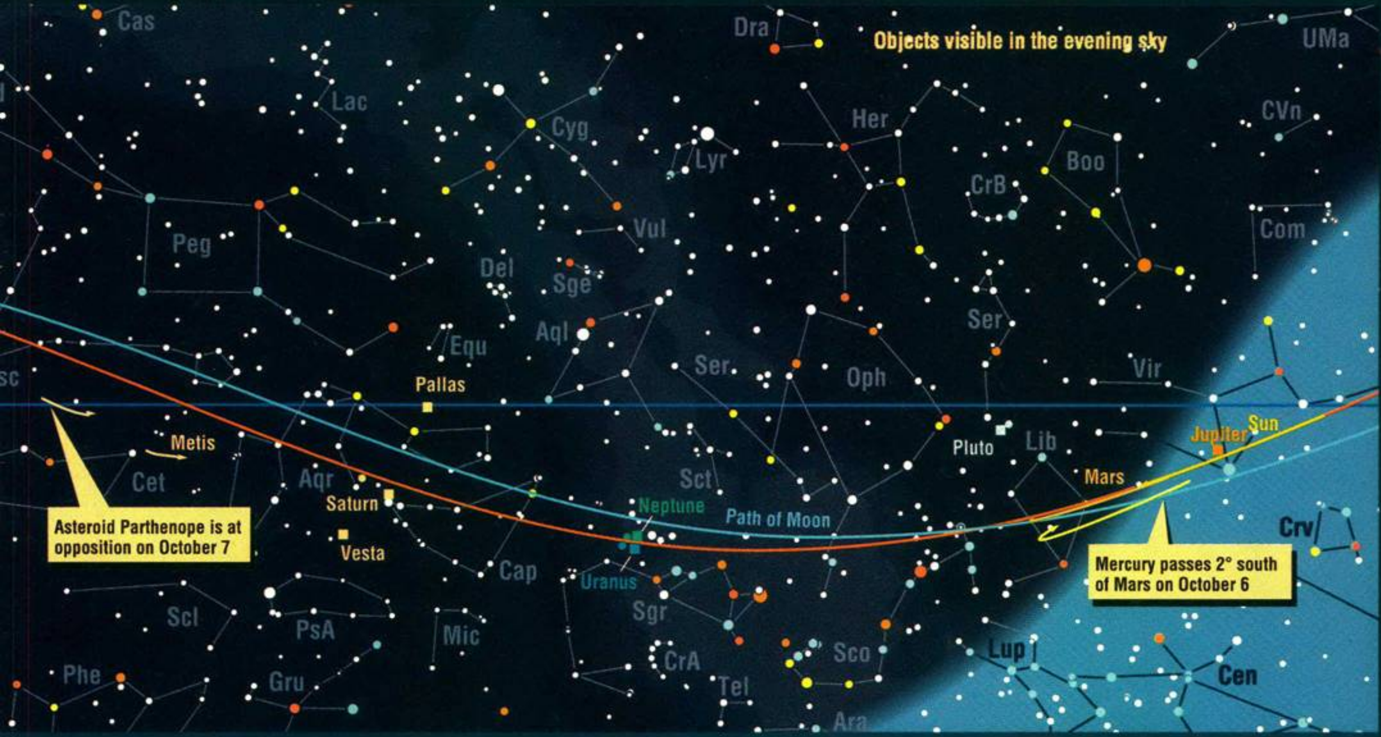
N

PLANETS	MERCURY	MERCURY	VENUS	MARS
Date	October 1	October 15	October 15	October 15
Magnitude	-0.1	0.0	-3.9	1.6
Angular Size	5.6"	6.8"	11.0"	3.9"
Illumination	79%	60%	92%	99%
Distance (AU) from Earth	1.202	0.990	1.523	2.430
Distance (AU) from Sun	0.466	0.430	0.719	1.537
Right Ascension (2000.0)	13h49.2m	14h52.8m	11h58.1m	14h39.3m
Declination (2000.0)	-12°57'	-19°37'	1°50'	-15°39'

Jupiter's Moons

Dots display positions of Galilean satellites at 1 UT on date shown. South is at top to match the view in a telescope.

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Oph
Vir
Pallas
Metis
Cet
Aqr
Saturn
Vesta
Sct
Neptune
Path of Moon
Pluto
Lib
Mars
Jupiter
Sun
Crv
Cap
Uranus
Sgr
Scl
PsA
Mic
CrA
Sco
Lup
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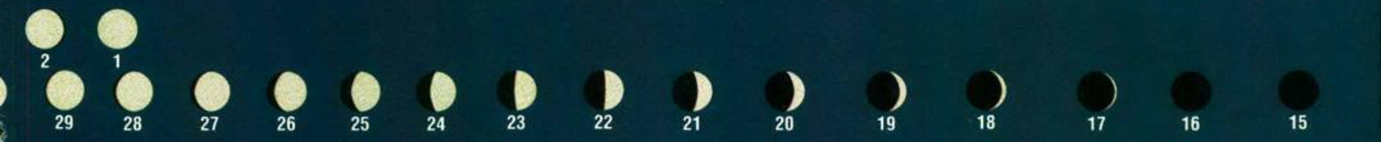
Tel
Ara

Objects visible in the evening sky

Asteroid Parthenope is at opposition on October 7

Mercury passes 2° south of Mars on October 6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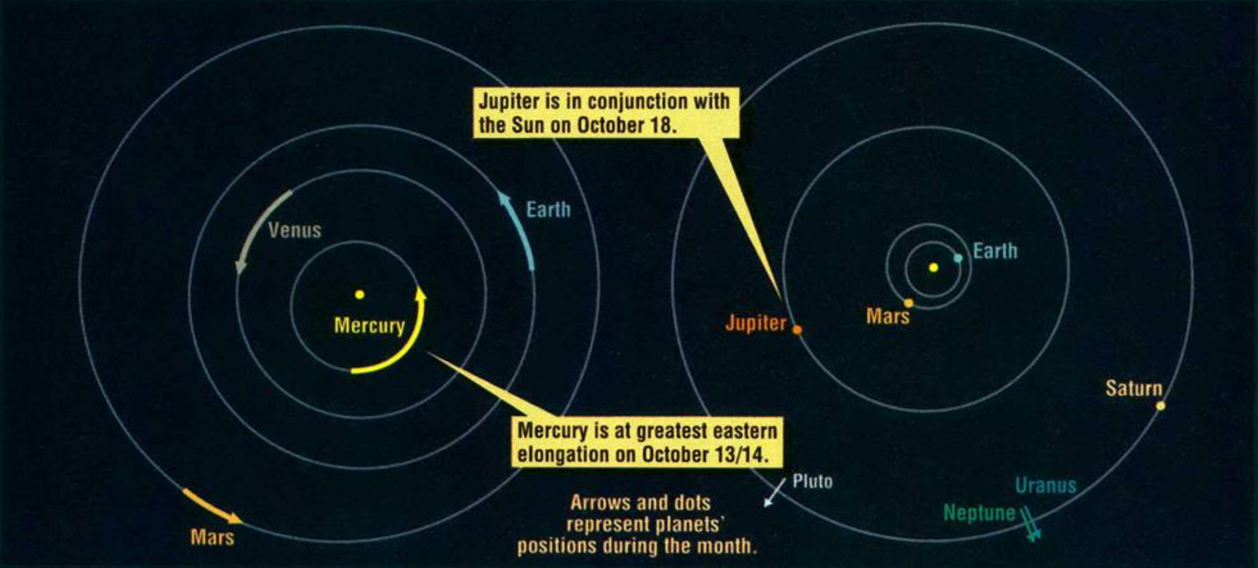
JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
October 1	October 15	October 15	October 15	October 15
-1.7	0.6	5.7	7.9	13.8
30.7"	17.9"	3.6"	2.2"	0.1"
100%	100%	100%	100%	100%
6.420	9.231	19.652	30.222	30.563
5.451	9.798	19.620	30.182	29.752
13h20.6m	21h46.8m	19h20.2m	19h19.9m	15h40.9m
-7°20'	-15°00'	-22°38'	-21°31'	-5°26'

The Planets in Their Orbits


Venus
Earth
Mercury
Mars
Earth
Jupiter
Mars
Saturn
Pluto
Uranus
Neptune

Jupiter is in conjunction with the Sun on October 18.

Mercury is at greatest eastern elongation on October 13/14.

Arrows and dots represent planets' positions during the month.

OVER THE EDGE

by David J. Eicher

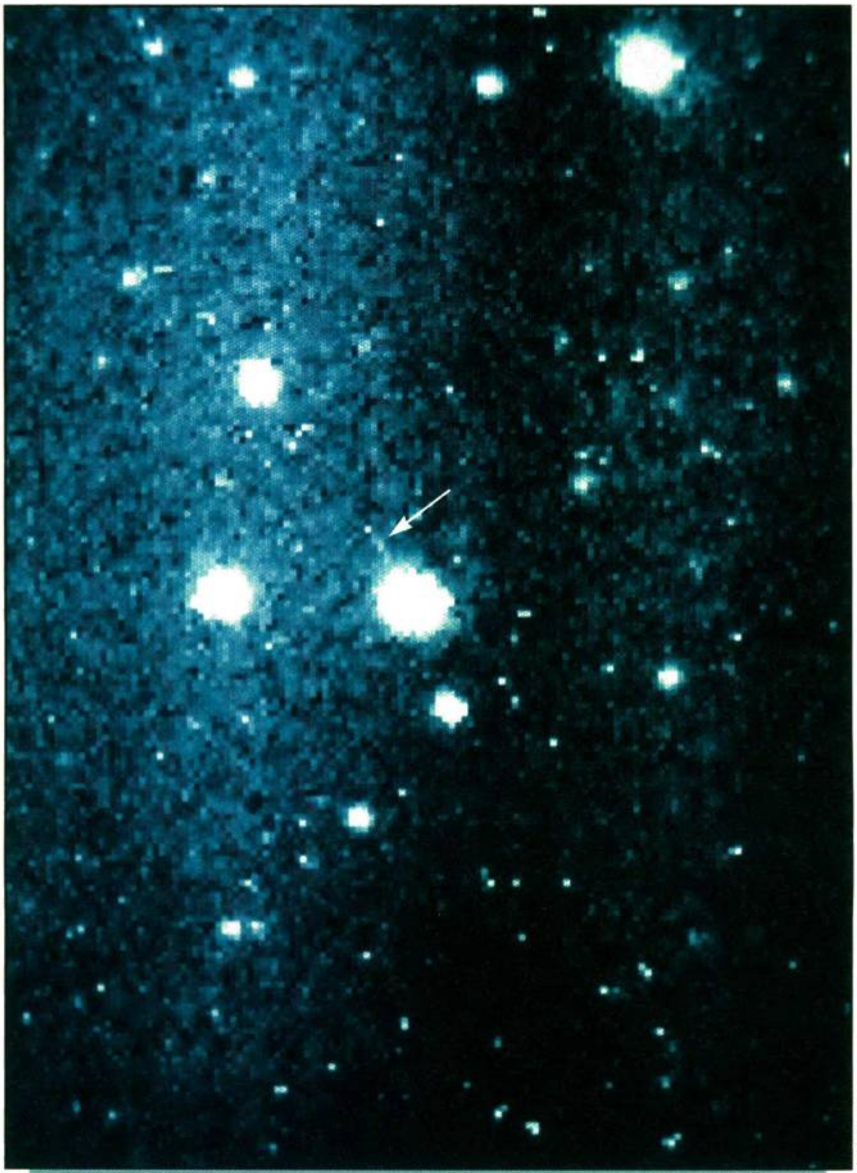
Poised at a crossroads of new and old technology, backyard astro-imagers are expanding the limits of recording galaxies on film and CCD chips.

Something's happening in amateur astronomy. Something big. Quietly, in the backyards of America and the world, stargazers are increasingly on edge. No — they're not going crazy. Rather, they're finding that a powerful combination of technology and awareness of deep-sky objects is enabling them to take home images of galaxies that would have stunned the previous generation of skywatchers. Images of galaxies and quasars that push astronomical imaging to the edge of the Local Group, the edge of the Virgo Cluster, and indeed, toward the edge of the universe.

Yeah. People always claim there's a revolution going on, right? But in backyard astro-imaging there really *is*. Over the past year or two, high-quality, affordable CCD cameras have hit the market that enable astro-imagers to capture color images of galaxies in the span of a few minutes' exposure.

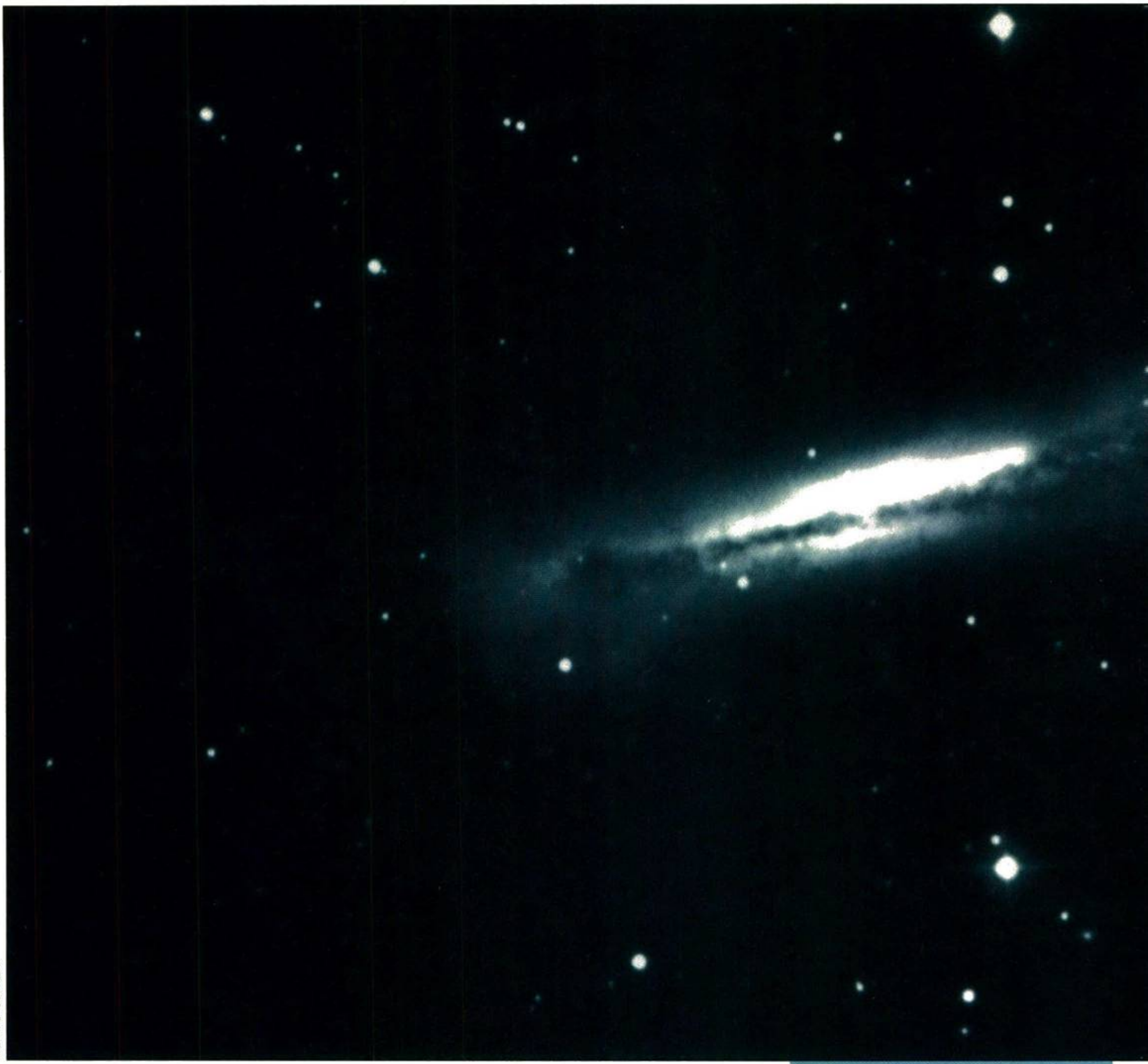
To create a color image, you need simply to take three monochromatic images of the same object through red, green, and blue filters, and combine the exposures electronically. (See "The Digital Darkroom," March and April 1993.) This permits exceptional control of the color balance in faint objects — much better than that of standard film. And by keeping the exposure times short, the new generation of CCDs helps us produce more frames in a given imaging session.

THE EDGE-ON SPIRAL NGC 2683 in Lynx represents a class of often-overlooked galaxies too dim to be showpieces and too bright to be challenging. CCD processing lets a short, high-resolution exposure accurately record dust along the galaxy's disk.



Jack Newton

A DISTANT QUASAR'S JET glows faintly as a line of pixels in this CCD image. Although it is the brightest quasar, 3C 273 in Virgo is about three billion light-years away. The ultrafaint jet, sprouting above and left (arrow) of the bright core, results when the massive object inside the quasar is ejecting material into deep space.



Martin C. Germano

A DEEP CONVENTIONAL EXPOSURE of Leo's NGC 3628 shows not only the galaxy's bright central bulge but also its gritty dust lane and smooth, warped outer envelope of nebulosity. Longer exposures and focal lengths and autoguiders are enabling backyard skyshooters to preserve on film finer details in old favorites.

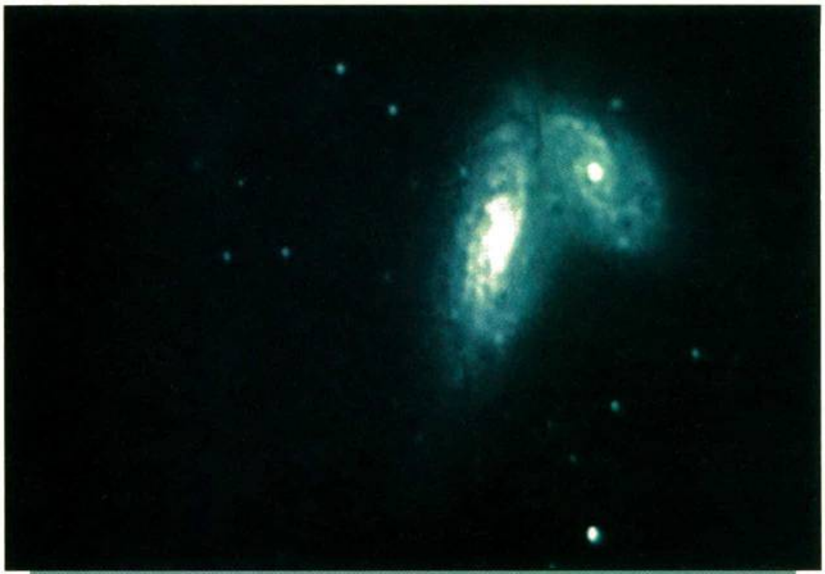
Moreover, and perhaps most importantly, the digital nature of CCDs means that fine details in galaxies such as the wavy edges of a dust lane are captured precisely in terms of digital brightness. A longer, conventional exposure might be more likely to blur such details as seeing and tracking fluctuate. The short exposure times offered by CCDs are also attracting astro-imagers with long focal length systems, who can now record galaxies at very large image scales (read: in great detail) with reasonable exposure times of 10 to 20 minutes.

Does the CCD explosion mean that conventional photography is outmoded? Not at all. Many astro-imagers have continued producing impressive work on ordinary film, mostly black-and-white, hypersensitized Tech Pan.

The route these conventional astrophotographers have taken focuses on high-quality information. It's a revolution of awareness in that many people are becoming aware of, and photographing, lesser-known objects. Instead of producing thousands of nearly identical M31 images each year, astro-imagers are now imaging Maffei I, NGC 520, NGC 2623, NGC 4567/8, and NGC 2683. That's very good to see, and it means that black-and-white photography is becoming much more exciting in content and composition.

Another part of the revolution in

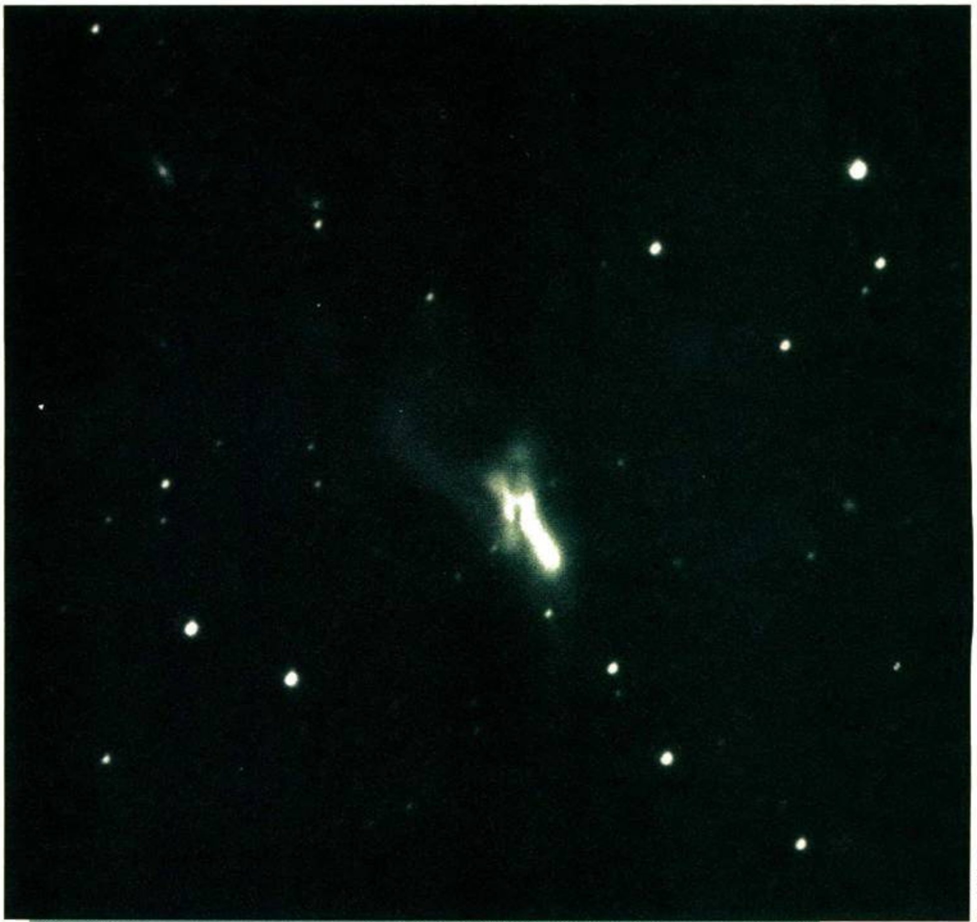
TORN APART AGES AGO, the oddball galaxy NGC 2623 in Cancer consists of three galaxy remnants that merged in an ancient collision. The object's wispy tails arc outward from the center.



Jack Newton

CHALLENGING GALAXIES like NGC 4567 and NGC 4568 in Virgo were once the province of professionals. Now they are being captured on the computer screens of hobbyists. Capturing detail such as spiral arms, dust lanes, and interaction between galaxies in objects as distant as the Virgo Cluster opens a frontier in imaging.

James R. Foster

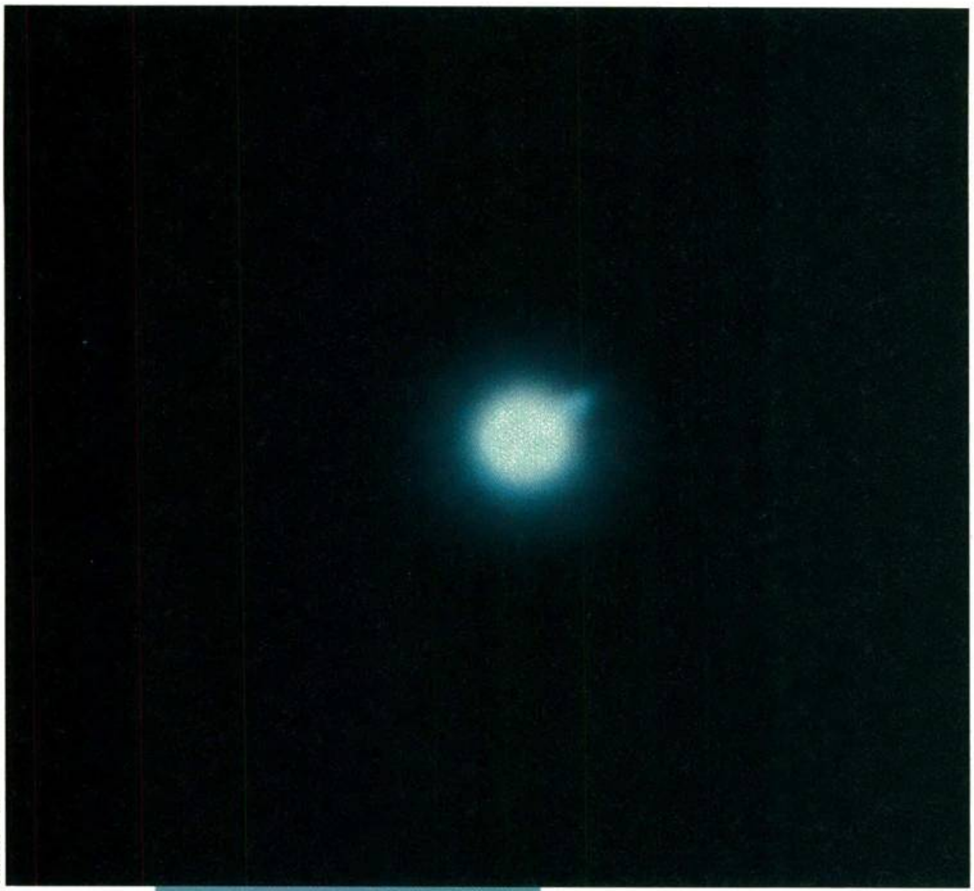


David Healy

COLLISION OR CENTRAL UPHEAVAL? Misfit galaxy NGC 520 has long puzzled astronomers because of its chaotic appearance. Some even claim that three quasars, near NGC 520 in the sky, were ejected from the galaxy's center. But most astronomers believe that NGC 520's freak shape is the result of an old collision between two galaxies.

THE WHIRLPOOL GALAXY (M51) in Canes Venatici is a longtime favorite for backyard astrophotographers. This CCD frame is a composite made from three 10-minute exposures, one each in red, green, and blue light. Such electronic compositing retains inner and outer detail and an authentic balance of colors.

Jack Newton



Jack Newton

SUPERMASSIVE GALAXY M87, the central object in the Virgo Cluster, typifies the bland, featureless nature of elliptical galaxies. Smooth globes of stars and gas, these objects defy observers wishing to see detail. Yet this backyard CCD image plainly shows the most significant — and challenging — detail in M87, its faint jet. The high velocity discharge was likely produced by a massive black hole in the galaxy's center.

HIDDEN GIANTS, galaxies Maffei I (right, arrowed) and Maffei II (left, arrowed) remained undiscovered behind the thick Cassiopeia Milky Way until 1968. Luminous outlying members of our own Local Group of galaxies, these faint fuzzballs would outshine most galaxies were they not hidden by the obscuring dust of the Milky Way.

Martin C. Germano

conventional astrophotography relates to technology. After 20 years of experimentation, automatic guiders for backyard telescopes have finally become highly reliable and affordable. This takes much of the tedium out of deep-sky astrophotography and allows exposures to go as long as the photographer wants or circumstances permit. In the four conventional photos in this article, the exposures ran 60 minutes, 90 minutes, 90 minutes, and 195 minutes. Such long exposures at long focal lengths capture spectacular details within faint objects that amateurs didn't even try to photograph ten years ago.

The improvement in backyard astro-images isn't limited to a gradual climb. The CCD imaging revolution is producing breakthroughs, too. Jack Newton, an astro-imager living in Sooke, British Columbia, is experimenting with color imaging of galaxies. Newton uses a 25-inch f/5 reflector and an ST-6 CCD camera, and typically processes his composited images with Hidden Image, a powerful new software program that sharpens stars and maximizes detail in both bright and faint areas of a galaxy. With this setup, it is now possible to record the jets in M87 and the distant quasar 3C 273, two targets that were off in "pro-territory" only a few years ago.

"The era of great galaxy imaging is still to come," says Newton, who believes his attempts of the last several months are still crude. "The capabilities are growing every day," he says.

Backyard astronomers now stand on the border between one era and the next. Whether or not digital imaging takes center stage, or when that might happen, is of little consequence to most amateurs. They seem satisfied with the fact that both techniques, CCD imaging and conventional astrophotography, are pushing astro-imaging over the edge and deep into the former territory of professionals. Clearly over the coming months we're going to see much sharper, more colorful images of galaxies. And not just from observatories, but from amateurs. That's something big. ☐

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Schmidt-Cassegrains — Celestron pioneered these fantastic instruments, and has an enviable reputation for building unsurpassed, exquisitely fine Schmidt-Cassegrain optical systems.

Refractors — Celestron's high-performance refractors are superb all-purpose telescopes, for astronomical or terrestrial observing. Built to standards that far exceed other telescopes in their class.

Reflectors — Celestron's popular reflector telescopes feature superior optical performance and full-featured, precision equatorial mounts which permit a full complement of optional accessories including electronic drive systems.

TeleVista II 60mm Refractor

Equally at home viewing the rings of Saturn or boats across the bay. Quality 25mm (28x) 1.25"eyepiece, all metal optical tube and yoke mount, finder scope, adjustable tripod, diagonal prism.

#9075 ***$ call***

Sky Explorer II 60mm Refractor

Ideal for lunar and planetary study, plus it's a powerful terrestrial telescope. 900mm f.l, 6x30 finder; star diagonal ; two eyepieces, equatorial mount; setting circles; tripod; and lighted accessory tray.

#9076 ***$ call***

SpaceProbe II 4.5" Reflector

Great 4.5" f/8 reflector, ideal for planetary and deep space. Equatorial mount, slow motion controls, setting circles. 6x30 finder plus 25mm (36x) and 9mm (100x) 1.25" eyepieces. Deluxe tripod.

#9078 ***$ call***

Sky Explorer II 80mm Refractor

Perfect for planetary and lunar observation. Bigger equatorial mount than competitive models, two 1.25" eyepieces, 6x30 finder, star diagonal, deluxe tripod and accessory tray.

#9077 ***$ call***

New! *Orion*
6", 8", 10", & 12.5" Dobsonian Telescopes

#9901 ***$ call*** 6" f/8

#9903 ***$ call*** 10" f/5.6

#9902 ***$ call*** 8" f/6

#9904 ***$ call*** 12.5" f/4.8

Prices include precision helical focuser and 25mm Sirius Plossl eyepiece — an $87 value!

These prices are not a misprint! Ideal for both beginners and advanced astronomers, these great new scopes offer high performance and lasting value. Precision 1/8-wave accurate reflector optical systems are ideal for both planetary and deep space observation. Image quality rivals scopes selling for four times their price. Huge light grasp for superb images of faint celestial subjects. See the Great Nebula in Orion in incredible detail. Get lost in the cloud belts of Jupiter. Lunar craters so detailed, you'll think you're in orbit!

Precision Dobsonian-type mounts are the finest in their class. Teflon zero-backlash bearings make it a breeze to track objects without wobble or vibration. Much more stable than comparable equatorial scopes. Lightweight, rugged, easy to transport and set up. Complete instruction manual.

Built to last a lifetime. Primary and secondary mirrors are aluminized and SiO overcoated for durability. Cabinet-quality laminate finish resists dirt and moisture.

Packing & UPS Shipping to any address in the 48 states: 6"—$39. 8"—$49 10" & 12.5" — call for charges.

DEEP SPACE EXPLORER™

Incredible Value!

Shown with optional finder scopes

The 6" model is the ideal beginner's or family scope - and is incredibly low-priced. Weighing only 29 lbs. complete, it's easily moved or handled by anyone. The 8" model offers 77% more light grasp, but is still a reasonable 39 lbs. and is only slightly larger.

The 10" and 12.5" models are perfect for those who can observe from darker sky locations. While heavier and larger than the smaller models at 68 and 85 lbs., they offer tremendous performance for their low prices.

MONEY BACK GUARANTEE
If you are not completely satisfied with your purchase from Orion, for any reason,
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Just return it in new condition within 30 days after delivery for a full refund.

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IN CALIFORNIA: 800-443-1001

Huge Selection of Astronomy Binoculars

New! 50mm Orion Observer™ II Binoculars — 7x, 10x, & 12x

Fine quality, moderately priced binoculars, excellent for both astronomy and daytime observation. Fully coated optics, unique hand strap for a secure and comfortable grip.

7x50 #9643 ***$ call***
10x50 WA #9644 ***$ call***
12x50 WA #9645 ***$ call***

50mm Explorer™ Binoculars

Our newest high performance binoculars with BAK-4 prisms and Multi-Coatings. Great for both astronomy and daytime observation. Comfortable ergonomic body design.

7x50 #9306 ***$ call***
10x50 #9308 ***$ call***

50mm Adlerblick Binoculars

Incredible wide field eyepiece design, Fully Multi-Coated, BAK-4 prisms, and best special glass objective lenses make the 7x50 Adlerblick the arch rival of European brand binoculars selling for 3-4 times the price. Orion buys direct, saving you money. Includes deluxe hard case, lens caps and straps.

7x50 #9612, *10x50* #9610 ***$ call***

Orion® 8x56 Mini Giants

56mm objective lenses gather over 2.5x the light of ordinary 7 x 35 binoculars. Perfect for viewing faint celestial objects, daytime viewing. Best Multi-Coated BAK-4 optics. 6° field of view. Standard model 33 oz. Rubber Armored for protection from bumps. Weighs 37 oz.

Standard Model #9504 ***$ call***
Rubber Armored Model #9627 ***$ call***

Orion® 70mm FMC Giants

The standard for hand-holdable astronomy binoculars. Fully Multi-Coated. 33% lighter—weighs only 58 oz.—yet the same brightness and 7mm exit pupil as our 11x80 MC model. Superior 'BCF' body design. Includes: soft rubber eyecaps, tripod mounting adapter, durable hard carrying case, lens caps and straps.

10x70 #9501, *14X70* #9594 ***$ call***

80mm FMC Giant Binoculars

20% more light transmission than ordinary "fully coated" binoculars. Fully Multi-Coated optics and superior BAK-4 prisms provide fantastic contrast and greatly improved edge sharpness.

11x80 MC- Brightest, widest field available. Ideal for deep-space observation under dark skies. Hand-holdable. #9502 ***$ call***

16x80 MC- 45% higher power, excellent for astronomy and daytime observation. Tripod recommended. #9496 ***$ call***

20x80 MC- Highest power model perfect for smaller deep-space objects and long range daytime views. Tripod required. #9498 ***$ call***

10x70 Military-Spec Binoculars

Light enough to hand hold, yet powerful enough to bring in remarkable views of deep space celestial objects. With military-grade optics, for the highest degree of optical accuracy and mechanical ruggedness. Will last through a lifetime of use, even under the most extreme environmental conditions. Absolutely waterproof and fogproof. With built-in folding rubber objective lens shades/dew caps. Includes deluxe case, photo tripod adapter. 7mm exit pupil. 5° field of view.

#9309 ***$ call***

SuperGiant™ 100mm Binos

Gigantic, almost 4" lenses gather 156% of the light of 80mm binoculars. Individual eyepiece focus, fully Multi-Coated optics and BAK-4 prisms. Tripod mounting plate, metal-clad case. Weight 7.5 lbs., height 13.5".

14x100 #9495, ***25x100*** #9497 ***$ call***
Shipped by FedEx only.

Observing Aids

NEW! Eyepiece/Accessory Cases

With patented unbreakable latches, die-cut foam inserts.
Inside Dimensions shown
11"x7"x3" #5951 ***$ call***
12.5"x9"x5" #5952 ***$ call***
16"x11"x5" #5953 ***$ call***

Orion® Dew Zapper

Gently replaces lost heat, a sure-fire cure for dew problems.

8" Dew Zappers —fit all Meade & Celestron 8" SCs DC #3503, AC #3504 ***$ call***

10" Dew Zappers—fit all Meade 10" SCs DC #3506, AC #3508 ***$ call***

12V DC Dew Gun.—#5601 ***$ call***

Orion® FlexiShield™ Dew Caps

Forms into a tube with Velcro closure, opens flat for storage and travel. Models to fit most telescopes.

8" Celestron/Meade SC #4200 ***$ call***

Other sizes available for scopes 3.5" to 14" —See our catalog for details

Scope Saver Telescope Covers

Keep the dust and dew away waterproof nylon covers; dr closure with cord lock.

8"Model
#15130 ***$ call***

10"-11" Model Fits Meade 10" and Celestron 11"
#15131 ***$ call***

Ask about other sizes.

Night Vision Flashlights

An essential accessory for astronomers. Choose from our wide selection.

Astronomer's Flashlight #5701 ***$ call***
Nitewriter Pen #5709 ***$ call***
Hands-Free Flex Light #5707 ***$ call***
Starlite LED Flashlight #5714 ***$ call***
Celestron LED Flashlight #5720 ***$ call***

Observer's Chairs

Standard Model—Adjustable height center column and padded seat.
#5935 ***$ call***

Deluxe Model—Built for professional musicians. Extra heavy duty.
#5934 ***$ call***

Components

Parabolic Primary Mirrors

Excellent hand-figured parabolic mirrors guaranteed to meet theoretical limits of resolution. Fine polished, coated twice: with Aluminum and Silicon monoxide. Very competitively priced! *See catalog for pricing.*

Standard Primary Mirrors
Made from fine soda-lime plate glass, 1:8 thickness ratio. Guaranteed 1/8 wave. Sizes: 6" f/8, 8" f/6, 10" f/4.5, 12.5" f/6.

Pyrex Low Expansion Mirrors
Made from fine annealed Pyrex brand low expansion glass, 1:8 thickness ratio. Guaranteed 1/10 wave. Available with 94% reflectivity Enhanced Aluminum coatings. Sizes: 6" f/5, 6" f/8, 8" f/6, 10" f/4.5, 10" f/6, 12.5" f/6.

Elliptical Secondary Mirrors

Made from fine annealed Pyrex brand glass, aluminized and SiO overcoated. Guaranteed 1/10 wave accuracy. Available with Enhanced Aluminum coatings. Nine sizes from 1.00 to 4.00" minor axis. *See catalog for pricing.*

Finder Scopes

These are high-quality finders at incredibly low prices! Fully coated wide field achromatic optics with adjustable focus. Precision crosshairs. White enameled metal tube.

6x30mm — Same unit used on $1000+ "big name" telescopes. With 2-ring bracket, fits scopes 6"-12". #13023 ***$ call***

6x30mm Right Angle — 90° prism for right-angle viewing. Includes bracket. #13021 ***$ call***

NEW! 8x50mm — 2.7x light grasp of 30mm models. Bright 6.25mm exit pupil. #7090 ***$ call***

NEW! 8x50mm Illuminated—Wireless illuminator with adjustable brightness. #7092 ***$ call***

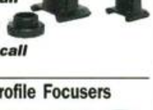
NEW! 9x60mm — 44% more light grasp than 50mm models. #7091 ***$ call***

NEW! 9x60mm Illuminated—Wireless illuminator with adjustable brightness. #7093 ***$ call***

Mounting Brackets - 2-ring design with non-marring adjusting screws. Fits any scope 6" and over including Celestron & Meade SCs

8x50mm bracket #5040 ***$ call***
9x60mm bracket #5041 ***$ call***

Rack-and-Pinion Focusers



Finest in their class. Diagonal-cut plated brass racks, oversized knurled knobs, long focus travel.

1.25" #13007 ***$ call***

2.0" includes 1.25" adapter. #13003 ***$ call***

NEW! Low-Profile Focusers

Perfect for fast optical systems. Ideal replacements for "Odyssey" scopes.

1.25"-#13014 ***$ call***
2.0" - #13016 ***$ call***

Accessories

See Our Catalog for Even More!

45° Erect Image Diagonal Prisms

See the world as it really is with Orion's 45° erect image diagonal. Ideal for all refractors and compound telescopes used for terrestrial viewing.
1.25" Diagonal #8790
.965" Diagonal #8791
Hybrid 1.25"/.965" Diagonal #8792
$ call

90° Star Diagonal Prisms

Orion's multi-coated diagon let you view at a right ang from the direction you telescope is pointing. The image is backward. Ideal for refractors and Schmidt-Cassegrains used for astronomical viewing.

1.25" Star Diagonal #8763 **$ call**

.965" Star Diagonal #8761 **$ call**

Hybrid 1.25"/.965" Star Diagonal #14008 **$ call**

2" Prism/Mirror Diagonals

2" Prism Diagonal–Absolutely the finest quality multi-coated 2" prism for highest light transmission.
For refractors #8770
For Schmidt-Cass. #8771
$ call

2" Mirror Diagonal– Affordable, high-quality star diagonal.
For refractors #8773
For Schmidt-Cass. #8772
$ call

Universal Camera Adapters

For prime focus or eyepiece projection astrophotography.
.965" #5268 **$ call**
1.25" #5264 **$ call**
Hybrid 1.25"/.965" #8782 **$ call**

Variable Power Camera Adapter

Allows variable projection distances during eyepiece projection photography. For 1.25" eyepiece holders.
#5262 **$ call**

Tele-Extenders

For high powered photography with your Meade, Celestron 4", 8", 10", 11", 14" Schmidt-Cassegrain.
Standard Tele-Extender #5125 **$ call**
Variable Tele-Extender #5127 **$ call**

T-Adapters

Threads to rear cell of telescope, requires t-ring for your camera model.
for SC #5116, *for C-90* #7115 **$ call**

T-Rings

Available for many different camera types, call toll-free or see our catalog for your particular model.

Multi-Function Focal Tester

Allows easy, accurate, ultra-sharp focusing, essential for astrophotography.
#7109 **$ call**

Tripods

Bogen/Velbon/more!
Huge selection of tripods available, for telescopes, spotting scopes and giant binoculars. Choose from assembled models or mix-and-match pan heads and tripods, sold separately. See our catalog for details.

Orion Slow Motion Adapter

Attaches to your photo tripod pan head. 2 slow motion control knobs to make precision adjustments in altitude an altazimuth. Very handy for tracking planets, the Moon, etc. with refractor telescopes and small spotting scopes. Attact with a standard 1/4-20 thread
#7012 **$ call**

Extension Cable for Slow Motion Control

12 3/4" flexible cable, for tracking at high powers. Buy 2, one for each axis.
#5014 **$ call**

StereoScope Viewer

For comfortable two-eyes-open observing. You won't believe the views! Threads securely to the rear cell of your telescope. Requires two identical eyepieces.
#9720 **$ call**

f/6.3 Reducer/Corrector

Get f/6.3 performance from your f/10 Schmidt-Cassegrain.
#5120 **$ call**

New! Sky Wizard™

Electronic Finder & Sky Catalog

Let Sky Wizard do the work, while you relax and have fun observing!

Orion's new Sky Wizards are electronic marvels that will put the magic back in your astronomical observing!

- Find any celestial subject in 15 seconds!
- One minute setup — no polar alignment or levelling.
- Observe hundreds of objects in a few relaxed hours — without using star charts!
- For ANY telescope, with or without a motor drive. *Even altazimuth or Dobsonian scopes!*
- Digital display of celestial coordinates (RA & Dec).
- Built-in electronic sky catalog — find subjects by their common catalog name, not their coordinates. Complete with object descriptions.
- Powered by a single 9v battery. Weighs just 6 oz!

Complete system requires Sky Wizard Model 1 or 2 and a telescope installation package, sold separately.

Encoders and cables available separately for custom installations. Call for details.

Sky Wizard Model 1
Includes the Messier Deep Space Catalog of 110 objects, 28 bright stars, and the planets.
#7801 **$ call**

Sky Wizard Model 2
Huge 2100+ object database, plus a user catalog to store 27 objects of your choice.
#7802 **$ call**

Installation Packages
Includes 2 encoders, all required mounting hardware and brackets, connecting cables, and complete illustrated instructions.

Celestron Super Polaris	#27100	**$ call**
Celestron Ultima 8" & 11"	#27101	**$ call**
Celestron Classic 8" & Powerstar 8"	#27102	**$ call**
Meade 8" & 10"	#27103	**$ call**
Dobsonian (fits Coulter and most others) Call for stock # for your model		**$ call**

Installation packages available for other telescopes.

Orion Off-Axis Guider

Allows you to observe a guide star during photography. Multi-coated.
#5144 **$ call**

Orion UltraGuider

Wide-range lateral prism adjustment; precision helical focusing; adjustable camera focal plane position.
#5139 **$ call**

110v Motor Drive for Refractors

Fits Orion equatorial mounts, many others. Plugs into any standard AC outlet.
#17001 **$ call**

12 Amp Hour Porta Pac Battery

Ideal for high power-consuming accessories. With carrying case. Weighs only 10 lbs.
#2354 **$ call**

Filters

Glass Solar Filters

High-quality optical glass filters, for superb images of the sun with your telescope. Triple-coated with advanced scratch-resistant stainless steel alloy. Great for both visual and photographic use. Slide fits over the front of your telescope.
For 8" SCs #7713 **$ call**
For 10" SCs #7715 **$ call**
Many other sizes available—see our free catalog for details.

Moon Filters

Cuts 87% of the light from the Moon. Reduces glare by uniformly reducing light transmitted over the entire spectrum.
.965" #5664, 1.25" #5662 **$ call**

Color Eyepiece Filters

Highest quality precision-ground optical glass. Fully anti-reflective coated. Solar system observations are dramatically improved. Thread into the barrel of any standard eyepiece, or directly into a universal camera adapter.

.965" Basic Set of 4 Filters #80A Blue, #58 Green, #25 Red, #15 Yellow.
#5510 **$ call**

1.25" Basic Set of 4 *#80A Blue, #58 Green, #25 Red, #15 Yellow.* #5514
1.25" Expansion Set of 4 *#21 Orange, #47 Violet, #11 Yellow-Green, #82A Very Pale Blue.* #5516
1.25" Advanced Set of 4 *#8 Light Yellow, #23A Light Red, #38A Deep Blue, #56 Light Green.* #5570
$ call

Deluxe Set of 8 Filters for 1.25" Includes all the filters in our basic and expansion filter sets.
#5517 **$ call**

Full Set of 12 Filters for 1.25" Includes Basic Set, Expansion Set, Advanced Set.
#5575 **$ call**

2" Set of 4 Includes #80A Blue, #58 Green, #21 Orange and #12 Yellow.
#5513 **$ call**

Individual .965", 1.25" & 2" Filters- Many colors available, see our catalog for details.

SkyGlow™ Light Pollution Filters

Enhance your viewing of faint deep sky objects with the best broadband light pollution filter you can buy. Our SkyGlow absorbs frequencies emitted by city lights, allowing transmission of the rest of the visible spectrum, yielding dramatic results.

SkyGlow Broadband Filters—Photographic and Visual
For use in slight to moderately light polluted areas.

1.25" Broadband Filter–fits 1.25" eyepieces.
#5660 **$ call**

SC Broadband Filter–fits rear cell of Meade & Celestron SC scopes.
#5658 **$ call**

52mm Broadband Filter–For 52mm camera lenses. (Adapter rings available for other diameters.)
#5668 **$ call**

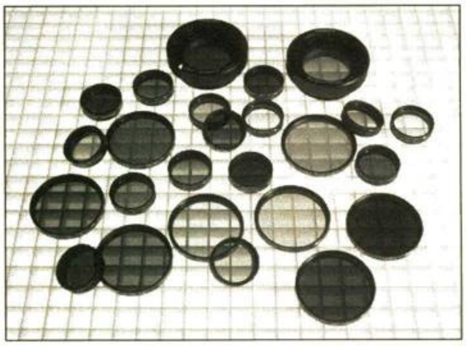
2.0" Broadband Filter–fits 2" eyepieces.
#5659 **$ call**

.965" Broadband Filter–fits .965" eyepieces.
#5661 **$ call**

SkyGlow UltraBlock Filters–Visual Only
For severely light polluted areas and faint nebulae.

1.25" UltraBlock Filter–fits 1.25" eyepieces.
#5654 **$ call**

SC UltraBlock Filter–fits rear cell of Meade & Celestron SC scopes.
#5656 **$ call**



Eyepieces & Barlows

✧ *Sirius*™ Plössl 1.25" Eyepieces

Fantastic Name-Brand Quality Eyepieces at an Incredible Low Price!

You could pay nearly twice the price for 'famous name' Plössl eyepieces, but we don't think you'll be able to tell the difference if you compare them to these fantastic eyepieces!

Sirius Plössls are top-quality, 50° apparent field eyepieces with extremely sharp images of impressively high contrast. Ideal for all types of reflector, refractor and catadioptric telescopes. The Plössl design is renowned for its fantastic performance and has in recent years become the standard by which all other eyepieces are compared.

Each eyepiece is of the classic 4-element Plössl design. Every air-to-glass surface is fully Magnesium Fluoride anti-reflection coated. All lens edges are blackened in the same way as expensive military optics, to further eliminate any scattering of stray light and to maximize contrast.

The optics are mounted in precision black anodized aluminum housings with chrome-plated brass 1.25" barrels for durability and precision fit.

We guarantee that you'll be impressed with the performance of the Sirius Plössls, even when compared to the more expensive name-brand Plössls.

25mm #8530, *17mm* #8531, *10mm* #8532, *7.5mm* #8533 **$ call**

Set of 4 in foam-lined case
#8534 **$ call**

Explorer .965" & 1.25" Eyepieces

These fine quality multi-coated eyepieces offer great performance at Orion's low direct-discount price. Three different optical designs are incorporated, to maximize efficiency in the various focal lengths. Black anodized, internally blackened, threaded for filters (except 40mm .965").

.965 Orthoscopic
5mm #8580, **7mm** #8581, **9mm** #8582, **12.5mm** #8583
$ call

.965 Kellner
18mm #8584, **25mm** #8585
$ call

.965 Achromatic Huygenian
40mm #8586
$ call

1.25" Orthoscopic
5mm #8500, **7mm** #8502, **9mm** #8504, **12.5mm** #8506, **18mm** #8524, **25mm** #8526
$ call

1.25" Kellner
6mm #8536, **9mm** #8538, **12mm** #8540, **18mm** #8508, **25mm** #8510, **40mm** #8512
$ call

Superb Ultrascopic™ Eyepieces

Unlike other premium eyepieces, Orion Ultrascopics offer complete multi-layer coatings on ALL surfaces, for superior light transmission and contrast. Modern 5- and 7- element designs for pinpoint star images and breathtaking detail. Wide 52° field of view. Guaranteed to beat other brands selling for much more! Unsurpassed high-performance design!

Medium-High Power 5-element
20mm #8566, **15mm** #8568, **10mm** #8570, **7.5mm** #8572 **$ call**

Wide Field 5-element
25mm #8564 **$ call**
30mm #8562 **$ call**
35mm #8560 **$ call**

***High Power 7-element** —Long Eye Relief*
5mm #8574, **3.8mm** #8576 **$ call**

MegaVista 1.25" & 2" Eyepieces

These outstanding eyepieces feature a 7-element design and incredibly sharp, fully multi-coated optics. The long eye relief and integral rubber eyeguards make these ideal for eyeglass wearers. The extra wide field of view (67°-70°) provides stunning images, perfect for deep space observing.
10.5mm 1.25" #8552 **$ call**
16.8mm 1.25" #8554 **$ call**
34mm 2" #8587 **$ call**
40mm 2" #8588 **$ call**

Illuminated Reticle Eyepieces

Orion offers 4 versions of the illuminated reticle eyepiece, a necessity for long exposure astrophotography and very useful for polar alignment. All have 1.25" barrels.

12.5mm Plossl Illuminated Reticle
Illuminator has fully adjustable brightness. Features double crossline reticle. Batteries included.
#8484 **$ call**

12mm Kellner Illuminated Reticle
Features double crossline reticle and red LED illuminator. Plugs into power panel drive bases.
#8482 **$ call**

9mm Orthoscopic Illuminated Reticle
Adjustable brightness illuminator. 'Bull's-eye within crosshairs' reticle. Needs 2 SR-44 batteries, not included.
#8488 **$ call**

6mm Orthoscopic Illuminated Reticle
Unique adjustable reticle system. Variable brightness. Needs 2 SR-44 batteries, not included.
#8487 **$ call**
SR-44 Batteries #2360 **$ call**

UltraZoom™ 7–21mm

The finest zoom you can buy for your 1.25" telescope. For astronomy or terrestrial observing. 65°-35° field. Fully coated.
#8556 **$ call**

See our free catalog for a fantastic selection of name-brand eyepieces!

CELESTRON TeleVue

Barlow Lenses

Orion offers a large selection of barlow lenses, allowing you to double or even triple the power of your eyepieces, maximizing the versatility of your collection. Available in .965", 1.25" and 2" diameters.

Fully Baffled 2x Barlow
Multi-coated, with internal baffling to block transmission of stray light. Premium performance at a remarkable price.
.965" #8740 **$ call**
1.25" #8746 **$ call**
2" #8724 **$ call**

Ultrascopic 2x Fully Multi-Coated Barlow
3-element Ultrascopic lens for superior images and precise color correction. Fully multi-coated optics, black anodized barrel. 1.25 barrel.
#8750 **$ call**

VariPower 2-3x Barlow
Allows you to adjust the magnification factor of the barlow by sliding the internal cell along a calibrated scale. Fully multi-coated optics. 1.25" barrel.
#8748 **$ call**

Shorty Barlows

The short bodies allow extra versatility: provides 2x magnification when the eyepiece is inserted directly, and 3x magnification when positioned before the diagonal on a refractor or SC. Will work in all telescopes, including those where longer barlows won't work.
.965" #8710 **$ call**
1.25" #8711 **$ call**

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#1 for Quality
#1 for Value
Orion accessories are absolutely guaranteed to be the finest quality available. Compare them side-by-side with "famous name" products! We buy direct from many of the same sources, always specify the highest quality, and pass along the savings to you! 100% satisfaction guaranteed!

Celestron's C5+ Telescope

Putting Celestron's new 5-inch Schmidt-Cassegrain telescope through its paces proved it to be a superb value for those looking for versatile optics in a compact, portable package.

by Alan Dyer

The C5 is back. First introduced in the early 1970s as part of Celestron's original line of orange-tube Schmidt-Cassegrains, the C5 proved to be a capable telescope with a reputation for fine optics. But the C5 always took a back seat to the then novel C8, with buyers of the day inevitably opting for the larger aperture telescope. Eventually, Celestron discontinued the C5.

But today many buyers are looking for compact but versatile telescopes either as easy-to-use and affordable first scopes or as portable second or third instruments to complement their large aperture telescopes.

Enter the C5 — or rather, re-enter the C5. Recently reintroduced by Celestron, the new versions of the C5 are ideal telescopes for many of today's buyers.

The C5 is now offered in three configurations. A spotting scope version which typically sells for about $750 is the lowest priced model. It consists of only the optical tube assembly and is intended for nature lovers looking for a telephoto lens or high-power telescope for terrestrial use.

The mid-priced C5 model (available for about $1,000) is the minimum configuration I would recommend for astronomical use. This version comes with a fork mount and an AC motor drive that enables the telescope to follow objects across the sky. Powering this telescope away from home requires an optional inverter to supply 110 volts AC from a source of 12 volts DC.

The top-end C5$^+$ differs only in its drive system. The Plus features a DC drive powered by an internal 9-volt battery. This telescope also comes with a hand controller and drive corrector electronics. These allow you to vary the speed of the motor to perform guiding corrections during long-exposure astrophotos. If you are interested in taking pictures through your telescope, this is the version you should consider.

I tested the C5$^+$ and found that at its typical street price of $1,200, the new C5$^+$ represents an excellent value in an all-purpose telescope.

The Optical Tube Assembly

Each of the three versions of the C5 features identical optics. The C5$^+$ I tested on loan from Celestron contained superb optics. At high power, stars exhibited a clearly defined Airy disk surrounded by a bright first diffraction ring and several successively fainter outer rings. Extra-focal star images were nearly identical on either side of focus with little sign of spherical aberration or roughness and with no trace of astigmatism, a flaw that makes star images look elliptical when thrown just out of focus. Jupiter snapped into crisp focus, showing wonderful detail in its equatorial belts. This was a telescope that demonstrated how well Schmidt-Cassegrain optics can perform and met Celestron's promise of diffraction-limited optics.

Focusing, accomplished by a knob that slides the primary mirror up and down the tube, was smooth and precise. When rocking the focus back and forth the image did not shift position. After releasing the focuser, the image did not creep out of focus as I have seen with some larger Schmidt-Cassegrains. The C5 focused down to a remarkable 8 feet, making it a unique "long-distance microscope" for daytime nature studies.

The straight-through 5x24 finderscope is small but adequate. It has a true 24mm aperture, unlike some 5x24 finders whose main lenses are stopped down to 10mm or so. Nevertheless, because of its greater light-gathering power, a 6x30 would be a better standard finder for this or any small telescope.

The rear cell of all the C5s uses the same threaded back as other Celestron and Meade Schmidt-Cassegrains, making the C5 compatible with accessories made for other Schmidt-Cassegrains — with one exception. Celestron pointed out that their off-axis radial guider produced for the C8 will not focus when used on the C5. Celestron has fashioned a special C5 model of the radial guider. This version features a shorter eyepiece tube and a prism that juts a little farther into the light cone. The C5 radial guider will work on a C8, however.

The One-Armed Mount

The most unusual feature of the C5 is the one-armed fork mount, a design Celestron borrowed from its long-discontinued C90 astronomical telescope. The tube assembly attaches to this fork via a metal bar on the tube that slides, dovetail fashion, into a channel attached to the fork arm. A bolt locks the tube in place and a safety bolt at each end of the dovetail bracket prevents the tube from sliding off should the main securing bolt come loose. This arrangement worked well and formed a solid, wobble-free connection. The dovetail setup also allows you to slide the tube back and forth by one inch to help rebalance the scope as you add or remove accessories such as cameras and eyepieces of varying weight. This is a handy feature.

The single-armed fork did have some bounce. After a rap to the tube,

COMPACT AND CAPABLE, the Celestron C5$^+$ is small enough to carry on an aircraft but large enough to show good planetary detail and faint deep-sky objects. The setup here includes the optional Vixen aluminum tripod and photographic accessories.

ASTRONOMY: Equipment photos by Darla Gawelski

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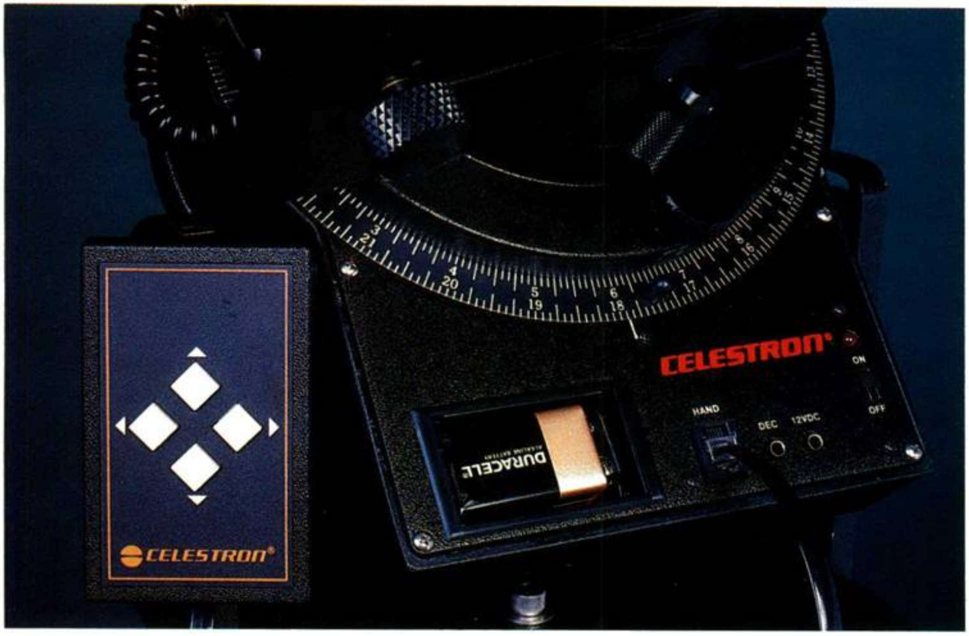
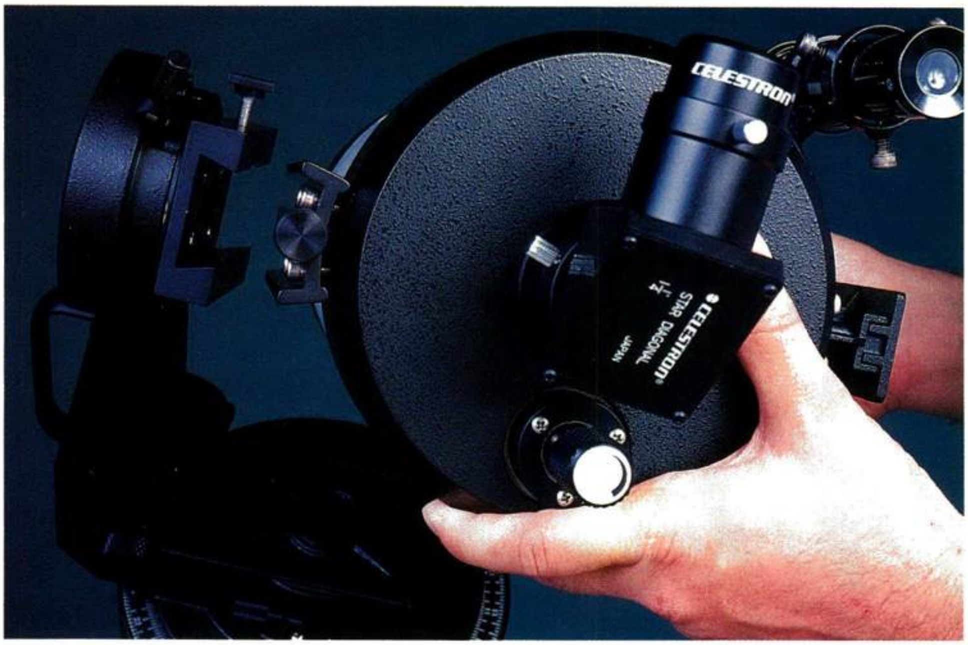


THE C5$^+$ CONTROL PANEL is a spartan affair, containing plugs for the hand controller, power supply, and optional declination motor, as well as the on-off switch. A compartment (shown with the cover removed) contains the 9-volt battery that powers the telescope.



THE TUBE CAN DETACH from the single-arm fork mount in seconds, allowing the tube assembly to be used as a 1,250mm telephoto lens. A dovetail bracket and bolt hold the tube firmly in place while two safety bolts prevent the tube from sliding out accidentally.

vibrations died out in three to four seconds. This was with the telescope mated to the optional aluminum tripod. Placing a set of Celestron's vibration suppression pads under the tripod legs cut the damping time to one second, making these a recommended accessory for the C5.

The C5 and C5$^+$ come with an aluminum tabletop wedge. This device tilts the telescope to aim the scope's polar axis at the celestial pole. The wedge is clearly marked with a latitude scale to aid in setting up the scope. For casual visual use, placing the C5 on a tabletop works fine, provided the table is solid. However, for photography, you need the optional tripod.

At 10 pounds, the aluminum tripod is light but sturdy. With its legs retracted, the C5's eyepiece ends up about 42 inches from the ground, ideal for viewing when seated. The legs can extend to raise the eyepiece to over 60 inches, high enough for stand-up viewing. However, the telescope is very shaky with the legs extended that far.

Precisely polar aligning the C5 is easiest by sighting the celestial pole through the finderscope. A polar alignment reticle, something the finder lacks, would make this process more accurate. To aim the telescope at the pole you can loosen the wedge and rotate it to provide about 5° of east-to-west adjustment. To move the scope up and down you can either adjust the tilt angle of the wedge (this requires the use of a hex wrench) or simply raise or lower the north leg of the tripod.

The mount comes with good setting circles. Both the 8-inch-diameter right ascension circle and 4-inch declination circle are clearly marked. The declination circle has a fixed pointer cast into the fork arm; the RA pointers, which include vernier scales, are stick-on labels.

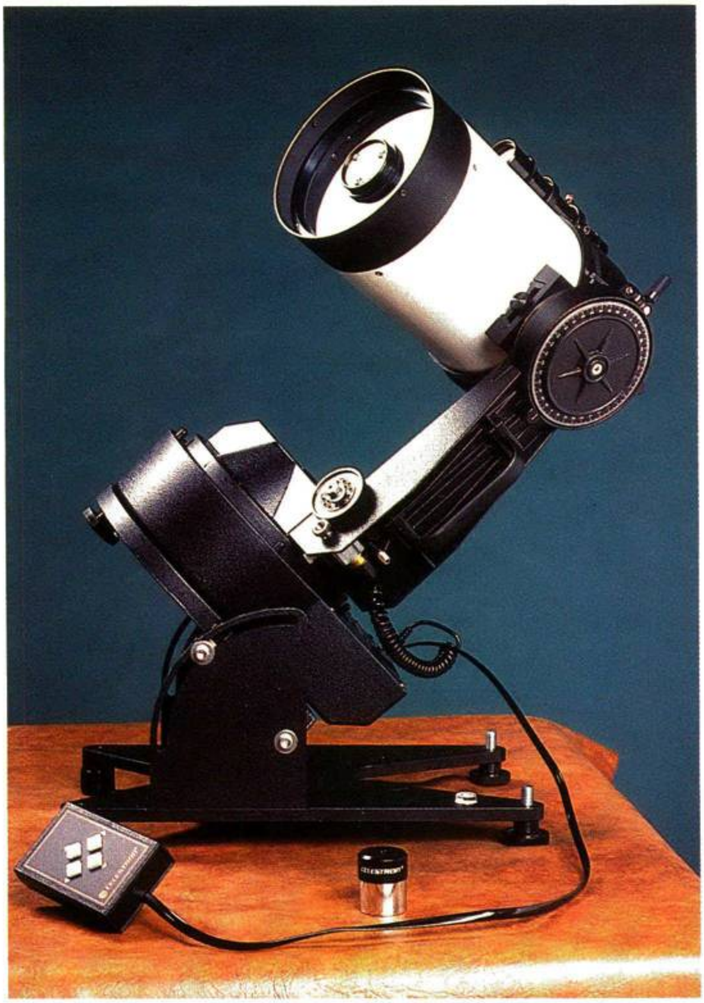
The locks on the RA and declination axes are similar to those on other Celestron Schmidt-Cassegrains. Both lock firmly, securely clamping the telescope even if it is out of balance. The manual slow-motion controls are smooth, with the RA motion being the coarse adjustment typical of all Schmidt-Cassegrains while the declination motion is a much finer tangent-arm adjustment.

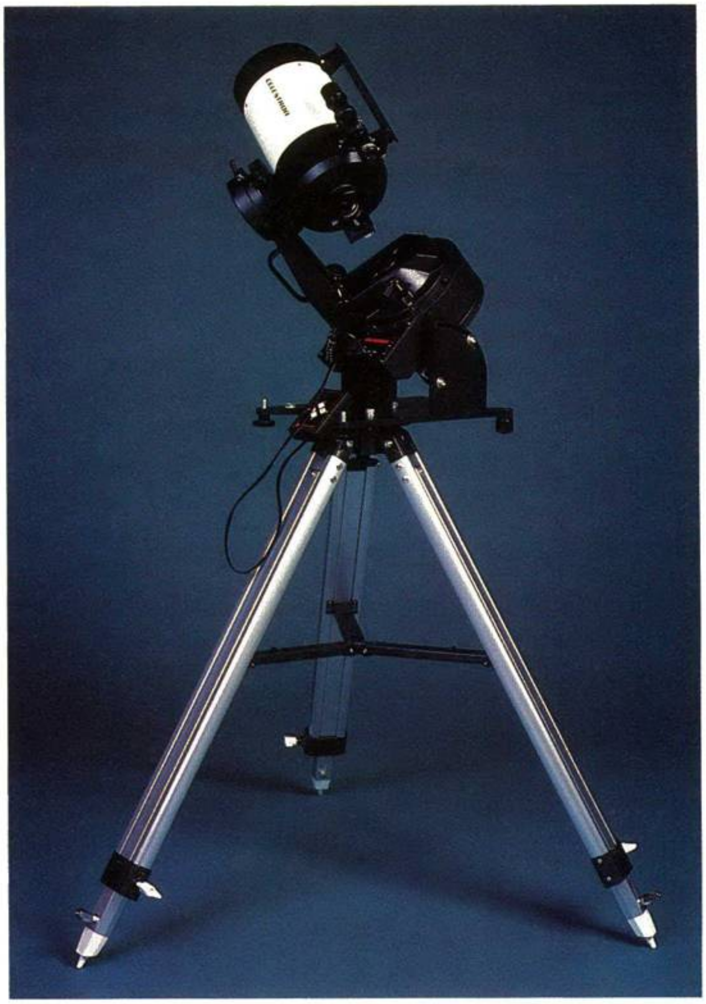
The Drive System

The DC drive of the C5$^+$ is designed with long-exposure astrophotos in mind. The east-west buttons on the hand controller speed up or slow down the RA motor speed by 40 percent of the sidereal rate, a fine adjustment ideal for astrophotography. An optional electric declination motor is available, which clamps under the fork arm and plugs into the control panel. With the Dec motor attached, the north-south buttons on the hand controller become active. The electric declination motion has a very slow speed that matches the RA control's speed. A clutch allows you to still use the manual Dec motion.

The electric motions in both directions were responsive and precise, with no backlash in RA and only a second or so backlash in declination. It was easy to guide this scope.

Note that the speed controls are useful only for guiding, not slewing. Unlike some of Celestron's more so-





THE STANDARD PACKAGE INCLUDES a tabletop wedge (left), which allows the telescope to be polar aligned and provides tracking capability for minimum cost and weight. You'll need to provide a solid table to place the scope on. The wedge assembly also bolts to the optional aluminum tripod (right) made by Vixen of Japan and offered by Celestron as a C5 accessory.

phisticated 8-inch telescopes, there are no high-speed 8x or 16x centering speeds. There is also no Periodic Error Correction circuitry nor solar or lunar drive rates. The C5$^+$ does allow you to reverse the direction of the drive motor for Southern Hemisphere operation, a switch accomplished by reversing a plug inside the base of the scope.

The C5 and C5$^+$ both use the same spur-gear drive system. The C5$^+$ I tested exhibited about 80 arcseconds of tracking error, a respectable figure for a small telescope. Most importantly, all of this error consisted of gradual drifts and was easy to guide out.

One of the best features of the C5$^+$ (so handy you might want to consider a C5$^+$ even if astrophotography is not one of your interests) is the built-in battery. Set up the telescope wherever you want, flip on the power switch, and the drive starts running. Not having to string cords from your house, car, or battery pack is a wonderful convenience. In warm weather, the internal 9-volt alkaline battery powered the scope for about 48 hours, just as advertised. Battery life will likely be less in winter.

Changing the battery is easy — a cover flips off the control panel, giving quick access to the battery. A 12-volt input jack on the panel allows you to power the scope from an external source if you wish.

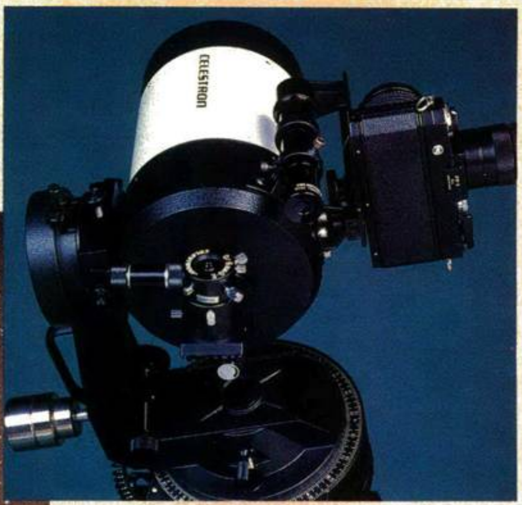
Taking Photos

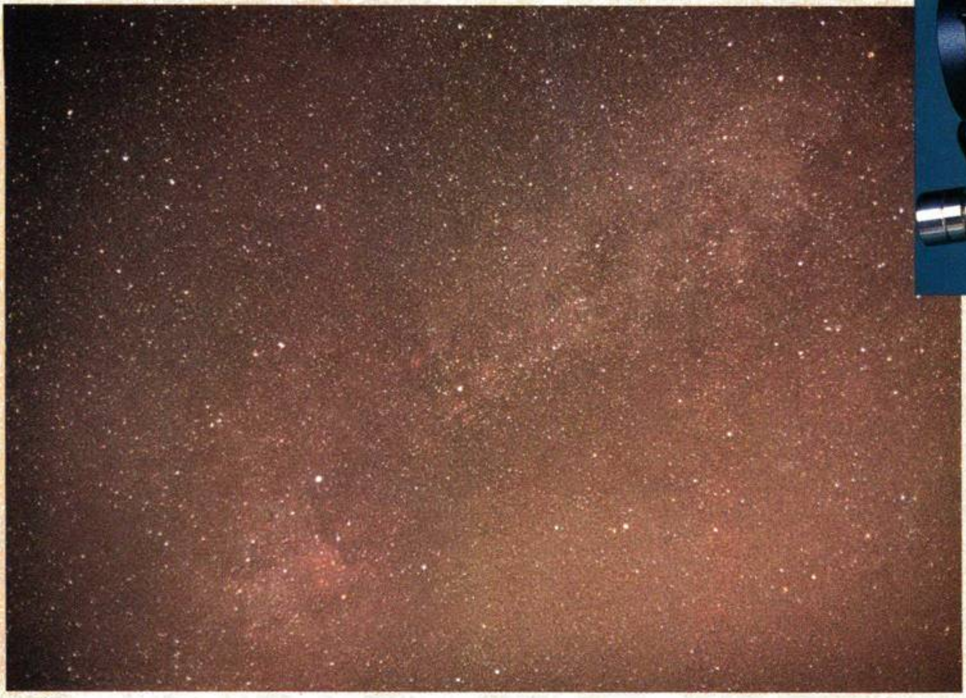
The C5$^+$ is designed to serve as a platform for piggyback shots. These are long-exposure deep-sky photos taken with a camera attached to the side of the telescope. This type of setup can record sweeping Milky Way vistas and entire constellations. Both the C5 and C5$^+$ come with a tube-length bracket to which you can bolt a camera with its lens. This bracket places the camera on the west side of the tube. To balance the camera, the optional piggyback kit includes a set of counterweights that screw onto the fork arm on the east side of the tube. These nicely balance the telescope in right ascension.

This arrangement mounts a piggybacked camera vertically, with the long dimension of a 35mm frame oriented north-south. This is fine for some photos but makes it impossible to shoot horizontal shots with north at top. A solution is to attach a ball-and-socket head to the piggyback bracket and then attach the camera to this head. You can then use the ball-and-socket's motions to twist the camera to frame constellations.

Another caveat comes when using a large lens, such as a telephoto, whose barrel extends below the level of the camera base. To prevent the lens from hitting the piggyback bracket, you need to bolt the camera at the top of the bracket with the lens hanging off the end. But, in this position, the extra mass makes the single-arm fork very bouncy and difficult to use if there's any wind. I found the C5$^+$ works best with small, lightweight lenses under 135mm focal

PIGGYBACK PHOTOGRAPHY

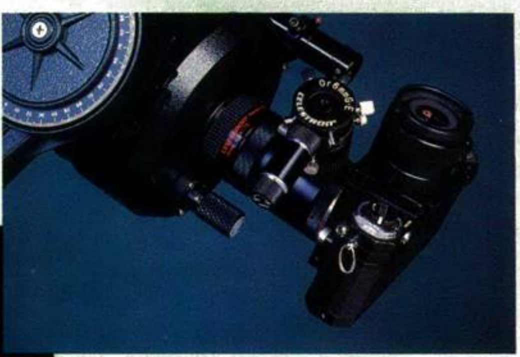


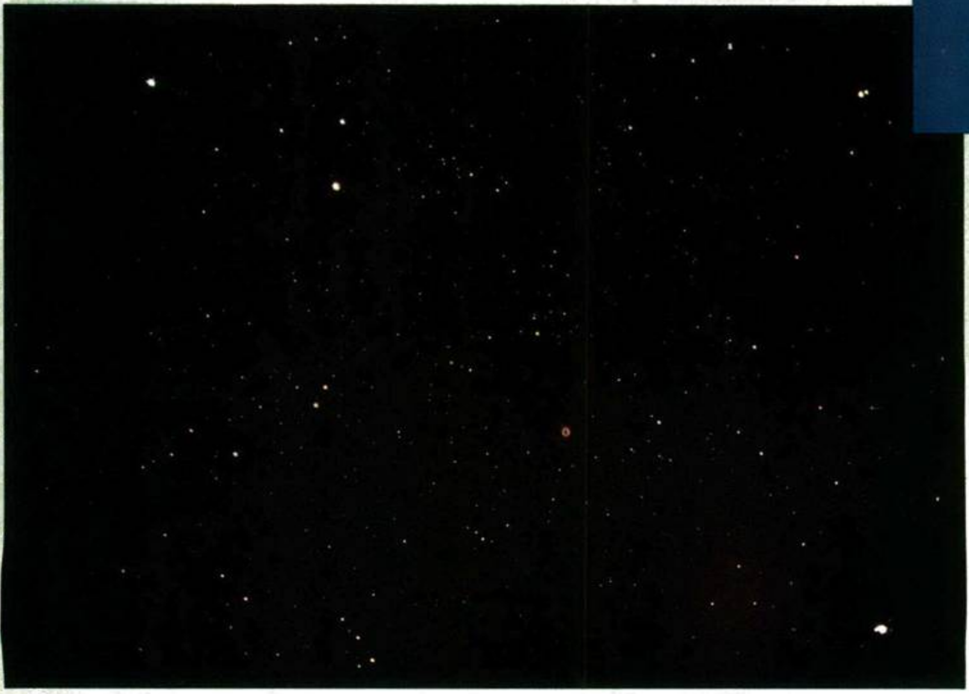


ASTRONOMY: Alan Dyer

FOR PIGGYBACK PHOTOGRAPHY, the camera bolts to a long bracket (as shown above) that runs the length of the west side of the tube. To balance the telescope, you need to add the optional counterweight to the fork arm on the opposite side of the tube. The test shot of Cygnus at left is a 3-minute exposure with a 50mm lens on Scotchchrome 1000 film. The C5$^+$ provided the tracking with no manual guiding.

PRIME FOCUS PHOTOGRAPHY





ASTRONOMY: Alan Dyer

PRIME-FOCUS DEEP-SKY SHOTS require the special C5 version of Celestron's radial guider as well as an illuminated reticle eyepiece. Celestron's f/6.3 reducer-corrector, used for this 25-minute test shot of western Lyra and M57, is a recommended accessory. The photo was manually guided using the C5's hand controller. The reducer produces some vignetting at the edge of the field; the guider's prism produced a slight internal flare.

CELESTRON C5^{+}

STANDARD SPECIFICATIONS

Aperture	5 inches
Focal ratio	f/10
Focal length	1,250mm
Secondary mirror obstruction	1.93 inches (38% by diameter)
Closest focus	8 feet
Finderscope	5x24
Size of eyepiece adapter	1.25 inches (fittings compatible with other SCTs)
Included eyepiece	one 25mm Kellner eyepiece (50x)
Clock drive mechanism	Spur gear drive
Clock drive motor	Battery-powered DC motor
Photographic field	1.6° x 1.0° (35mm film)
Field with f/6.3 reducer	2.5° x 1.7° (35mm film)
Weight of tube	6 lbs.
Weight of scope + wedge	23 lbs.
Length of tube	11 inches
Warranty	Lifetime
Suggested list price	$1,898
Typical selling price	$1,200

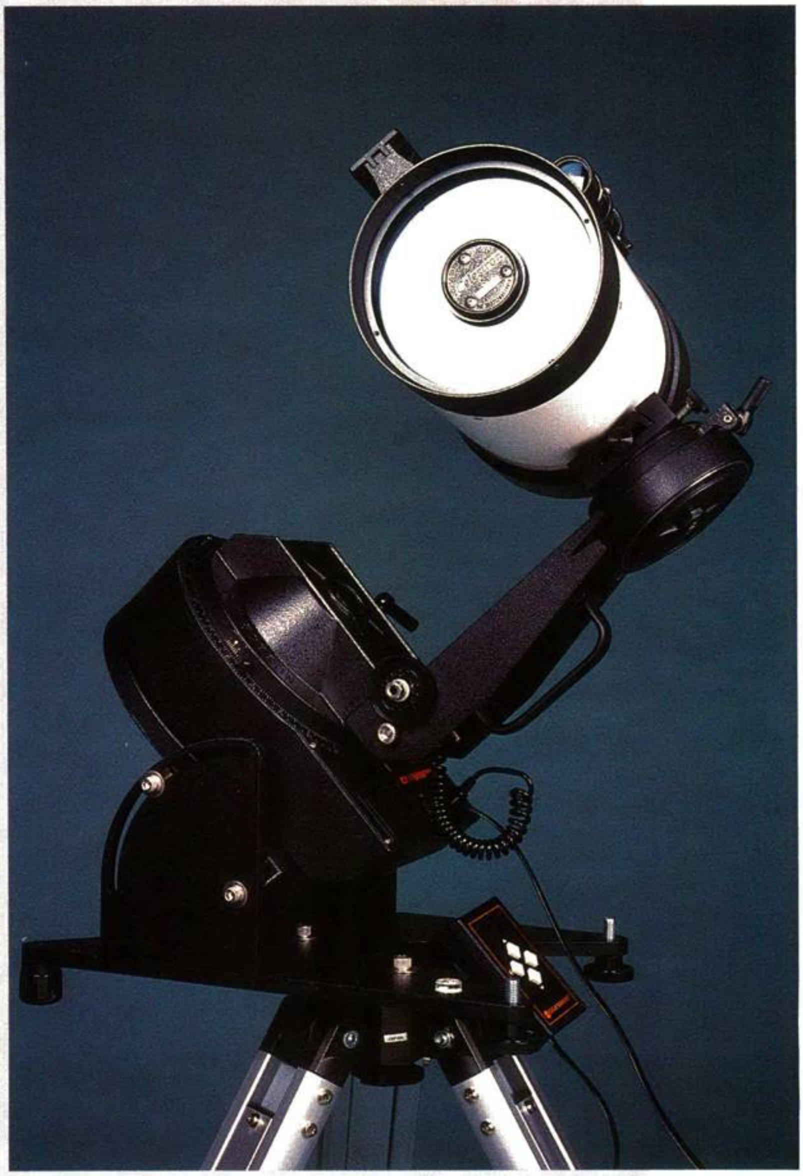
(Includes finder, eyepiece, star diagonal, hand controller, wedge, metal lens cap)

OPTIONAL ACCESSORIES

(Suggested list prices; actual prices vary with dealer)

Aluminum tripod	$398
Vibration suppression pads	$72
DC-to-AC inverter for C5	$130
AC-to-DC transformer for C5^{+}	$40
Car battery adapter for C5^{+}	$36
Dewcap/lensshade	$76
Full-aperture solar filter	$110
ABS plastic telescope case	$210
Electric declination motor	$150
Piggyback kit with weight	$90
Basic T-adapter for cameras	$50
C5 off-axis radial guider	$200
f/6.3 reducer-corrector	$250
6mm guiding eyepiece	$260

Celestron International, 2835 Columbia Street, Torrance, CA 90503, (310) 328-9560.



length. With these, the C5's drive system is accurate enough that no manual guiding is required — just open the shutter and walk away from the scope, provided, of course, the telescope is polar aligned.

As with any telescope, for deep-sky shots through the main optics, you do need to guide. I took test shots using a combination of Celestron's f/6.3 reducer-corrector, radial guider, and 6mm guiding eyepiece accessories. The reducer cuts down the C5's 1,250mm focal length to just under 800mm, a focal length much more forgiving of tracking error. Compared to the C5's normal f/10 focal ratio, the f/6.3 speed provided by the reducer also cuts exposure times by a third.

You Can Take It with You!

With its combination of fine optics, smooth drive system, and built-in drive corrector, the C5^{+} proved to be a good telescope for all kinds of astrophotography, one of the few available in the $1,200 price range. But if you are interested only in looking at celestial targets, the less expensive AC-powered C5 may be all the scope you need. Be sure to get the optional inverter if you plan to take it away from an AC outlet.

Either telescope provides a lightweight package that is about as convenient to use as an equatorial telescope can be. It's easy to carry this scope, tripod and all, from house to backyard and be observing a few moments later. I've frequently said that the best telescope is one that gets used often — the C5 and C5^{+} are telescopes designed to be used, anywhere, anytime, for all types of viewing and photography. Kudos to Celestron for bringing back this versatile telescope. ☐

Cool Sharp Nights

Yes, Virginia, you can observe deep-sky objects with your small refractor.

by Alister Ling

A gorgeous crescent Moon ripe with earthshine hangs low in the western sky. As it dips toward the horizon, glorious Saturn takes center stage in the south. But by mid-evening, even the ringed planet is sinking in the southwest, and brilliant Venus isn't scheduled to rise until the wee hours. If you're like many backyard observers with a small refracting telescope, you may think it's time to pack up. Although refractors are justly famous for providing crisp views of the Moon and planets, everyone knows they aren't much good on deep-sky objects, right? Wrong. Your 60mm to 90mm refractor is well suited for the deep sky. You just have to know which objects to look at and which to avoid.

The Best in Glass

But why use a refractor? First of all, a well-made refractor delivers sharp images. Stars tend to be very crisp points compared with the views through most other telescopes — rendering a beautiful sky. And refractors with shorter focal lengths (700mm to 900mm) can also give you a wide 1.5° to 2° field of view with low-power eyepieces. This means large sparkling clusters of stars appear nicely framed instead of magnified so much that you seem to look right through them.

The high-quality images refractors generally deliver allow you to crank up the power to explore the inner details of an object, as long as that object is bright. It's true that small and medium-sized refractors aren't big light buckets that can bring in faint galaxies, so observing extragalactic objects, particularly from the city, doesn't work very well. But something with a high surface brightness can look good even when you spread out its light with high magnification.

In short, the best deep-sky objects to view with a refractor are big star clusters like the Pleiades or objects with a high surface brightness like the Orion Nebula.

The Pleiades

by Mace Hooley

Clusters for Cool Nights

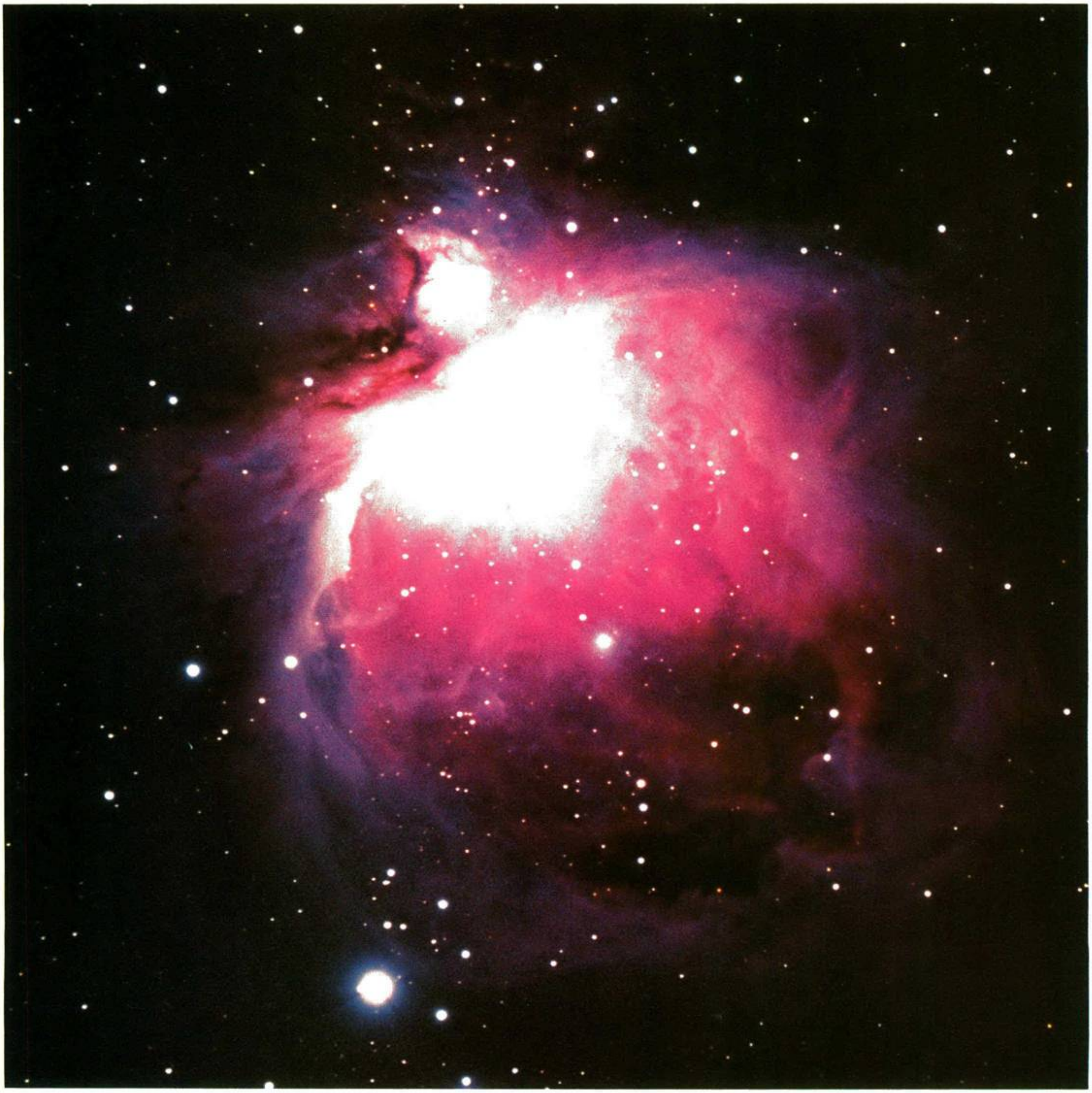
Star clusters remain the best targets for small-scope owners in the city because the points of light can pierce the haze of light pollution. In comparison, nebulae usually appear as gray blobs only slightly brighter than the gray sky.

No question — fall and winter's top cluster, indeed the best cluster for those with a small telescope, is the Pleiades, or Seven Sisters. This magnificent open cluster lies in the northwestern corner of Taurus, which you can find ascending in the east at mid-evening. I'm always amazed at how a small scope transforms the tiny dipper-shaped grouping of six stars you see with your naked eye into a rich scene of a hundred or more stars that fills your field of view. The lower the power you use on the Pleiades, the better. You might even consider buying an eyepiece with a long focal length, say 30mm or longer, to give you a wider field of view. The Seven Sisters appear at their best when you can see them all at once.

Second only to the Pleiades is the Double Cluster in Perseus. These two open clusters lie well up in the northeast on October evenings, roughly one-third of the way between the northern tip of Perseus and the "W" pattern of Cassiopeia. A wide field of view lets you see both of these magnificent sprays of stars at the same time. They make a perfect introduction to the variety of shapes and qualities seen in open clusters.

The brighter member of the Double Cluster, known as h Persei, is easily the more prominent of the two. Its central area contains a tight packing of stars. At magnifications over 100x, I always see a "stick man" with a round head, no neck, two thin arms, and two bowed legs. Fainter stars flow from the man out of the field of view.

Its companion, Chi (χ) Persei, is sparser and fainter than h. Instead of a central concentration, I see a hole in a large circlet, with a bow tie attached to one side. The bow tie contains two stellar triplets of nearly the same size and orientation. At higher magnifications, I can



The Orion Nebula
by Bill and Sally Fletcher

M36, M37, and M38
by D. B. Jamison

Double Cluster (h and χ Persei)

by Michael Stecker

Eskimo Nebula

by Jack Newton

Owl Cluster

by Lee Coombs

begin to see some stars filling in the circlet.

Now let's jump over the constellation border into Cassiopeia, to a spot just northwest of the star Phi Cassiopeiae. Here lies the Owl Cluster, or NGC 457, which denotes it as the 457th object listed in the *New General Catalogue*. Twenty stars stand out in a scattered pattern that resembles a figure with thin, outstretched wings. The two bright stars at the top — the eyes — give the Owl its name. By boosting the magnification up to 150x I can easily see several more stars including a couple of close pairs in the body.

Three bright open clusters populate the figure of Auriga the Charioteer. One is M38 (the 38th object catalogued by the 18th-century French astronomer Charles Messier), a large, scattered collection containing a wide range of bright and faint stars. M36, located just over 2° southeast of M38, appears noticeably different. M36 is smaller and brighter than M38, with a dozen bright stars punctuating its central regions. The best of Auriga's trio of open clusters lies less than 4° southeast of M36. M37 is an example of a rich cluster. At low power all you might see is a faint fuzz. But don't give up right away. A bit of patience at high power will reward you as dozens of faint stars come into view.

Orion's Great Nebula

As midnight approaches, the familiar form of Orion the Hunter begins climbing in the east. Orion contains a most delightful jewel, a vast cloud of gas and dust called The Great Nebula (M42), which can be seen with the naked eye as a fuzzy patch of light south of the constellation's prominent belt stars. At low power, M42 is a bright, moderately big gas cloud with a greenish hue that surrounds some diamondlike stars. Because my backyard is well lit with street lights, I can see only the central, bright area of the nebula. The curving tendrils seen in photographs call for a trip out to dark, country skies.

Still, you can easily see details in the nebula: A huge dark gap intrudes into the bright region. This feature, called the "Shark's Mouth," stands out even more if you increase the magnification beyond 120x. You'll see one or two stars poking out of the darkness. The nebula itself is definitely mottled and two of its edges form a sharp, 90° angle.

Also try glancing a bit to the side of M42, which will make use of the most light-sensitive part of your retina. With this averted vision, the nebula nearly doubles in size! If you stare directly into the heart of the Great Nebula instead, the four bright stars known as the Trapezium blaze away.

The Best of the Rest

Emission nebulae and clusters aren't the only objects with high-surface brightness you can see well in a small telescope. Many planetary nebulae — glowing shells of gas that have been puffed away from a dying star — are also worth pursuing. The name planetary nebula is really a misnomer. They are called planetaries because in a telescope, their small disks often resemble the outer planets Uranus and Neptune. Most of these deep-sky dwellers appear small and fairly bright, which lets them shine through light-polluted skies. The best planetary at this time of year is the Eskimo Nebula (NGC 2392), located in southern Gemini.

Its disk measures 15 arcseconds across, as big as the planet Mars was at opposition in early 1993, meaning at low power you can pick this up as a fuzzy star. Treat it as you would a planet and crank up the power. You'll see a bright central star surrounded by a fairly uniform circular disk.

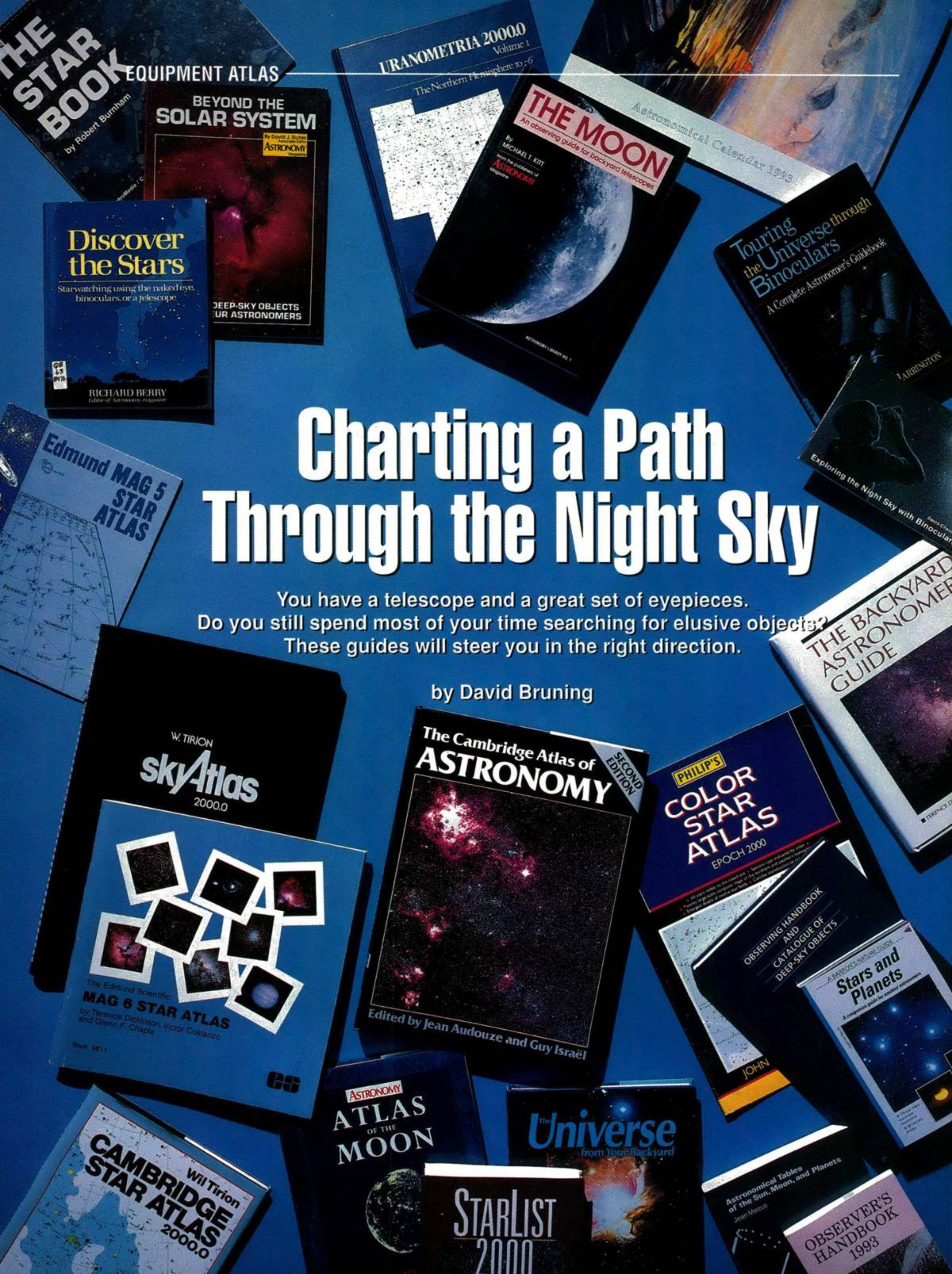
If you look directly at the central star the nebula disappears. As soon as you start glancing to the side, it returns — it seems to blink! The Eskimo Nebula is great for practicing your averted vision so you can see more in other objects.

As I mentioned earlier, any small, bright object is good for city observing, and double stars are no exception. A favorite of mine is Castor, the fainter of the sparkling twin stars in Gemini. At low power, Castor looks just like any other star. Up at 200x, you will see a fine pair of white stars, one slightly brighter than the other, separated by a thin dark lane of empty space.

A delightful way to end your night of observing is to watch Sirius twinkle as it comes up in the southeast after midnight. Earth's turbulent atmosphere acts like a rotating prism, making the brightest star in our sky change color constantly and randomly with all the colors of the rainbow, from violet all the way through red.

As you can see, the sharp images delivered by refractors let you observe deep-sky objects from your backyard or balcony. So next time the Moon and planets don't cooperate with your observing schedule, turn to some of the beautiful clusters and nebulae that adorn the winter sky. ☐

Alister Ling, an avid deep-sky observer, lives in Edmonton, Alberta. His last article for ASTRONOMY *was "Beautiful Bootes" in the May 1993 issue.*


THE STAR BOOK
by Robert Burnham
BEYOND THE SOLAR SYSTEM
ASTRONOMY
DEEP-SKY OBJECTS
UR ASTRONOMERS
URANOMETRIA 2000.0
Volume I
The Northern Hemisphere to -6
THE MOON
An observing guide for backyard telescopes
By MICHAEL T. KITT
From the publishers of ASTRONOMY Magazine
Astronomical Calendar 1993
Discover the Stars
Starwatching using the naked eye, binoculars, or a telescope
RICHARD BERRY
Touring the Universe through Binoculars
A Complete Astronomer's Guidebook
HARRINGTON
Exploring the Night Sky with Binoculars
Edmund MAG 5 STAR ATLAS
THE BACKYARD ASTRONOMER'S GUIDE
TERENCE D
W. TIRION
SkyAtlas 2000.0
The Cambridge Atlas of ASTRONOMY
SECOND EDITION
Edited by Jean Audouze and Guy Israël
PHILIP'S
COLOR STAR ATLAS
EPOCH 2000
OBSERVING HANDBOOK AND CATALOGUE OF DEEP-SKY OBJECTS
JOHN
A BARRON'S NATURE GUIDE
Stars and Planets
The Edmund Scientific MAG 6 STAR ATLAS
by Terence Dickinson, Victor Costanzo and Glenn F. Chaple
CAMBRIDGE STAR ATLAS 2000.0
Wil Tirion
ASTRONOMY
ATLAS OF THE MOON
The Universe from Your Backyard
STARLIST 2000
Astronomical Tables of the Sun, Moon, and Planets
Jean Meeus
OBSERVER'S HANDBOOK 1993

Charting a Path Through the Night Sky

You have a telescope and a great set of eyepieces. Do you still spend most of your time searching for elusive objects? These guides will steer you in the right direction.

by David Bruning

The most important accessory for your telescope isn't a finderscope, clock drive, or good set of eyepieces. What good are these when you don't know where to look in the sky to find the objects you want to observe?

Whether you're a beginning or an experienced observer, you need a basic set of atlases and guidebooks to help you get the most from your observing sessions. Of course, which guides and atlases you choose depends on your observing interests. So we've put together this guide to help you pick the ones you need.

Observing Guides

Guidebooks sift through the myriads celestial objects and single out a particular type of astronomical object or all the objects you can see easily with a particular instrument. Philip Harrington's *Touring the Universe through Binoculars* (John Wiley and Sons, 1990, 294 pages, $29.95, K) highlights over 1,000 deep-sky objects visible through binoculars. (The K signifies that Kalmbach Publishing Co., the producers of ASTRONOMY, sells these books.)

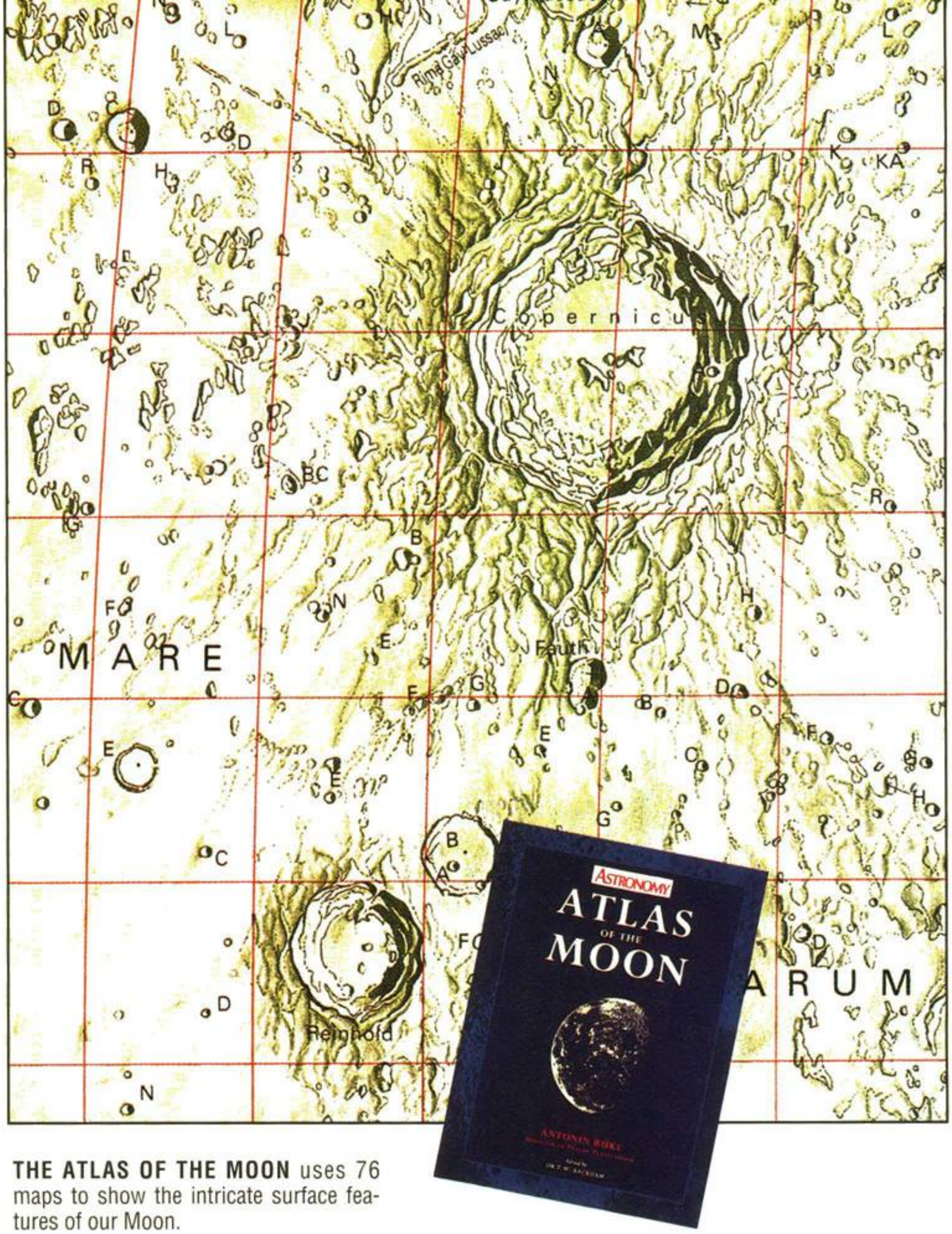
The Universe from Your Backyard by David J. Eicher (Kalmbach, 1988, 188 pages, hardcover, $29.95, K) provides beginning astronomers with maps showing where to find deep-sky objects accompanied by pictures and drawings of what you'll see. For advanced observers, *Stars and Galaxies* edited by David J. Eicher (Kalmbach, 1992, 200 pages, hardcover, $29.95, K) presents over 300 of the greatest deep-sky objects.

Lunar observers have a guidebook too, *The Moon* by Michael T. Kitt (Kalmbach, 1992, 80 pages, softcover, $11.95, K). Antonin Rukl's *Atlas of the Moon* (Kalmbach, 1990, 224 pages, hardcover, $29.95, K) forms an excellent companion to Kitt's book.

For learning the constellations, consider Robert Burnham's seasonal star dome maps in *The Star Book* (Kalmbach, 1983, 20 pages, softcover, $9.95, K) or Richard Berry's monthly star dome maps in *Discover the Stars* (Harmony Books, 1987, 119 pages, softcover, $12.95, K). Berry's book also has 23 maps for finding bright deep-sky objects to help you make the transition from naked-eye to telescope observing.

If you're looking for a sky guide to fit in a jacket pocket (okay, a big pocket), try Joachim Ekrutt's *Stars and Planets* (Barron's, 1992, 157 pages, softcover, $11.95, K). The monthly star dome maps and tables tell you where to find the planets through the year 2000.

ASTRONOMY: All photos by Darla Gawelski



THE ATLAS OF THE MOON uses 76 maps to show the intricate surface features of our Moon.

Observing Handbooks

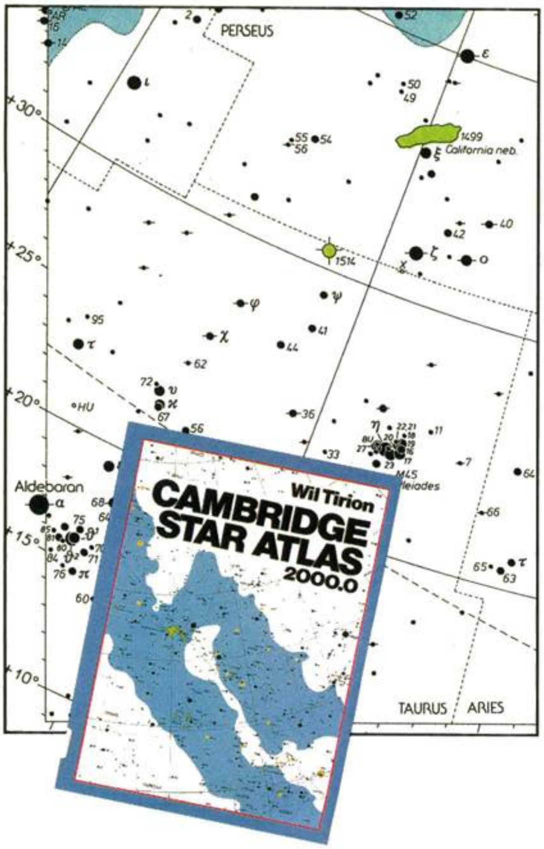
Handbooks pick up where guidebooks leave off and describe many more objects than you can find in the guidebooks. One of the most popular (actually a set of three volumes) is *Burnham's Celestial Handbook* by Robert Burnham, Jr. (Dover Publications, 1978, 2,138 pages, softcover, $13.95 per volume, K; and no, that's not the same Robert Burnham who heads ASTRONOMY). The book is getting a little dated now, but it remains a favorite of many observers.

Real deep-sky aficionados use Christian B. Luginbuhl and Brian A. Skiff's *Observing Handbook and Catalogue of Deep-Sky Objects* (Cambridge University Press, 1990, 352 pages, hardcover, $49.50, K) because of its extensive listing of galaxies, planetary nebulae, and star clusters. Observers of stars — doubles and variables — will find in Richard Dibon-Smith's *StarList 2000* (John Wiley and Sons, 1992, 400 pages, softcover, $29.95) indispensable lists of stellar properties, orbital diagrams, and variable-star tables.

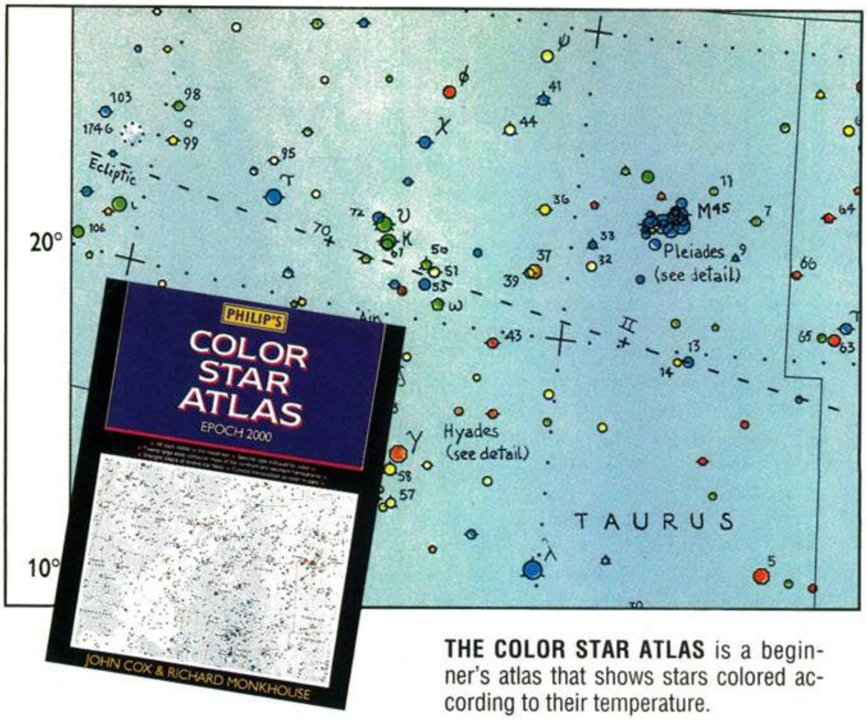
Almanacs

Which planets are visible tonight? When is the next eclipse? When does the next meteor shower occur? To find the answers to these questions, check an astronomical almanac. The *Observer's Handbook*, published each year by the Royal Astronomical Society of Canada, is *the* favorite of many backyard astronomers. The 1993 handbook cost $14.95 and had 236 pages of tables about planets, deep-sky objects, and double and variable stars.

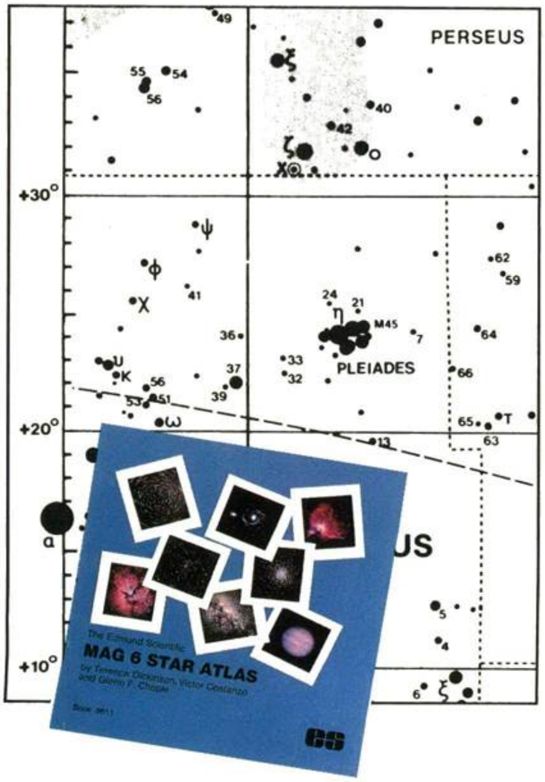
Naked-eye astronomers like Guy Ottewell's *Astronomical Calendar* (Astronomical Workshop, published each year, 70 pages, softcover, $16).


PERSEUS
California neb.
Aldebaran
M45
Pleiades
TAURUS
ARIES
Wil Tirion
CAMBRIDGE STAR ATLAS 2000.0

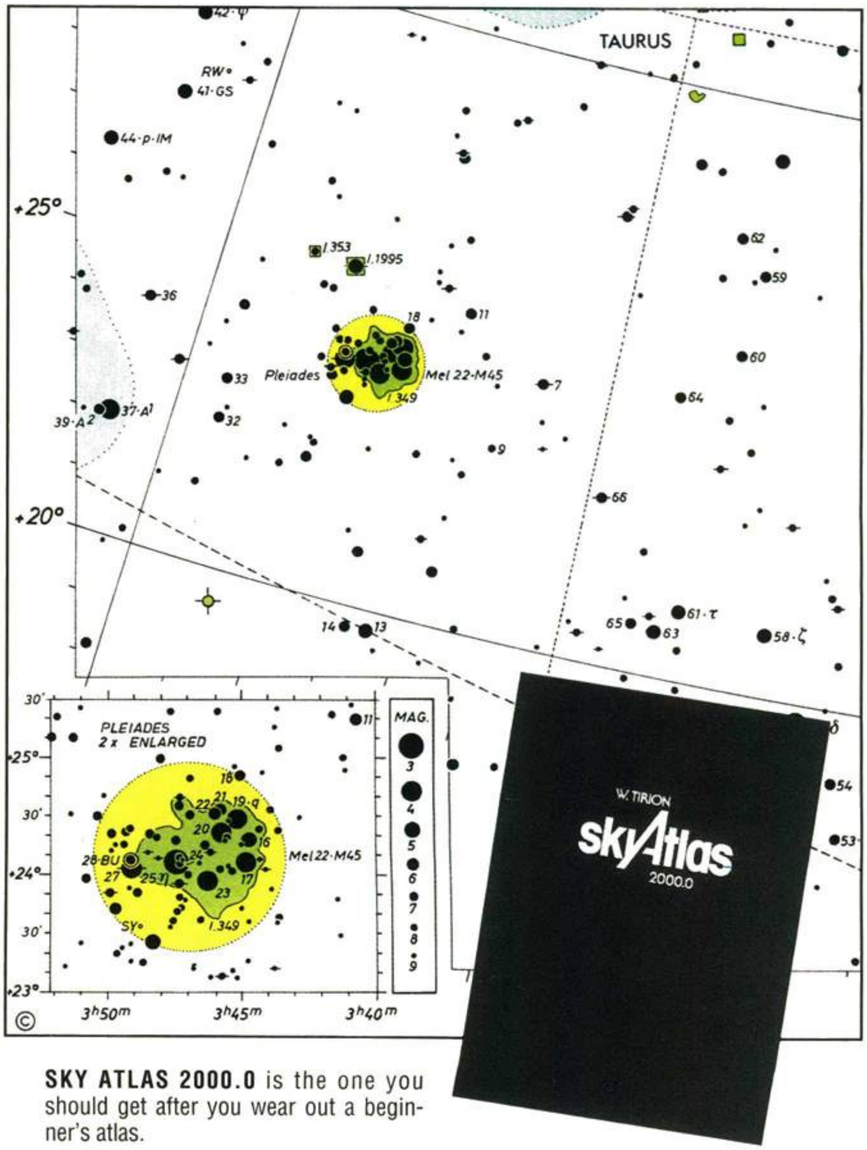
THE CAMBRIDGE STAR ATLAS 2000.0 provides color maps and is ideal for beginners. All atlas samples appear at their full size.


Ecliptic
M45
Pleiades (see detail)
Hyades (see detail)
TAURUS
20°
10°
PHILIP'S
COLOR STAR ATLAS
EPOCH 2000
JOHN COX & RICHARD MONKHOUSE

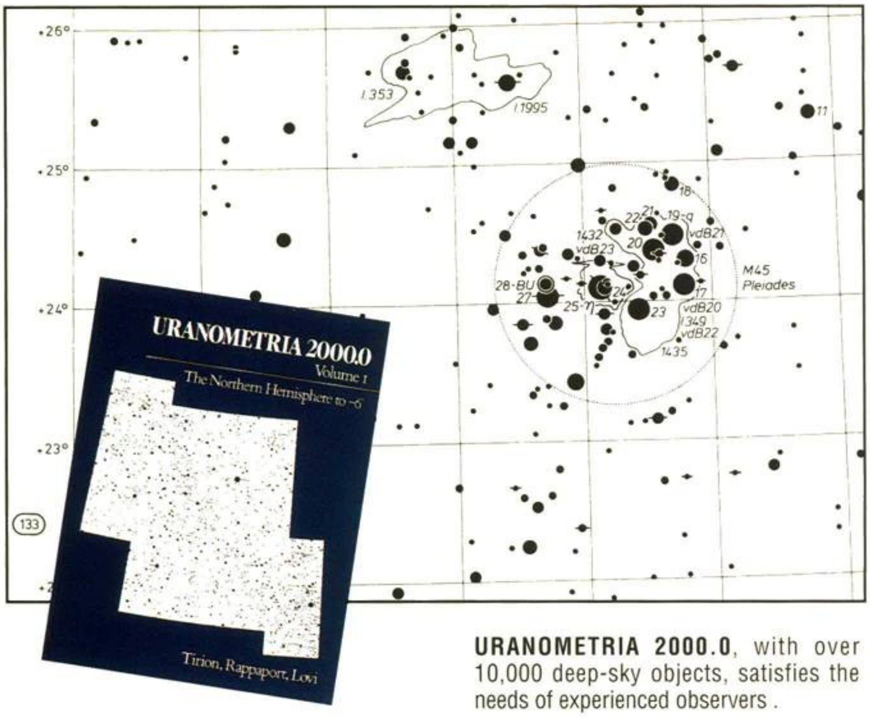
THE COLOR STAR ATLAS is a beginner's atlas that shows stars colored according to their temperature.


PERSEUS
PLEIADES
M45
+30°
+20°
+10°
The Edmund Scientific
MAG 6 STAR ATLAS
by Terence Dickinson, Victor Costanzo and Glenn F. Chaple

THE MAG 6 STAR ATLAS, a beginner's atlas, includes basic information about observing and astronomical objects.


TAURUS
Pleiades
Mel 22-M45
+25°
+20°
PLEIADES 2 x ENLARGED
MAG.
3h50m
3h45m
3h40m
W. TIRION
skyAtlas 2000.0

SKY ATLAS 2000.0 is the one you should get after you wear out a beginner's atlas.



URANOMETRIA 2000.0, with over 10,000 deep-sky objects, satisfies the needs of experienced observers .

Ottewell's famous diagrams show how comets zip through the solar system and why the inner planets appear where they do in the sky.

For astronomers wanting to look forward to eclipses and planetary alignments into the next century, Jean Meeus lists the dates of celestial events in his *Astronomical Tables of the Sun, Moon, and Planets* (Willmann-Bell, Inc., 1983, 398 pages, softcover, $19.95, K).

Atlases

Astronomical atlases are essential observing aids. They show individual regions of the sky, helping you to locate stars and deep-sky objects. Beginners should start with the *Cambridge Star Atlas 2000.0, Color Star Atlas*, or *Mag 6 Star Atlas*.

Wil Tirion's *Cambridge Star Atlas 2000.0* (Cambridge University Press, 1991, 74 pages, hardcover, $19.95) has 20 star charts that show over 9,500 stars down to magnitude 6.5 and 866 deep-sky objects. Colors and symbols help to differentiate between star clusters, nebulae, and galaxies, and object descriptions accompany each chart. Seasonal sky maps help you choose which star chart to use.

Another good beginner's atlas is Terry Dickinson, Victor Costanzo, and Glenn Chaple's *Mag 6 Star Atlas* (epoch 1950.0; Edmund Scientific Co., 1982, 66 pages, softcover, $17.95). It contains a guide to using your telescope in addition to 12 maps (in black and white) showing stars down to magnitude 6.2 and hundreds of deep-sky objects. It also provides object descriptions with each map.

The *Color Star Atlas* (epoch 2000.0) by John Cox and Richard Monkhouse (Kalmbach, 1991, 40 pages, softcover, $19.95, K) features stars plotted in color according to their temperature. It includes stars down to magnitude 6.75, star clusters and nebulae down to 9.5, and galaxies down to 11.5.

Sky Atlas 2000.0 by Wil Tirion (Cambridge University Press and Sky Publishing, 1981, softcover, $44.95, K) is a marvelous intermediate atlas. Its 26 maps show over 43,000 stars down to magnitude 8.0 and about 2,500 deep-sky objects.

Serious deep-sky observers refer to *Uranometria 2000.0* by Wil Tirion, Barry Rappaport, and George Lovi (Willmann-Bell, Inc., 1987; Volume I, Northern Hemisphere to −6°, 259 maps, hardcover, $39.95, K; Volume II, Southern Hemisphere to +6°, 259 maps, hardcover, $39.95, K). It plots stars down to magnitude 9.5 (and sometimes fainter) and over 10,000 deep-sky objects.

You'll Also Want

Every observer should have Terence Dickinson and Alan Dyer's *The Backyard Astronomer's Guide* (Camden House Publishing, distributed by Firefly Books, 1992, 295 pages, hardcover, $39.95, K). This book tells you everything you need to know about telescopes, observing techniques, and the basics of astrophotography.

You don't need to plod through a college textbook to learn about astronomy. *The Cambridge Atlas of Astronomy* edited by Jean Audouze and Guy Israël (Cambridge University Press, second edition, 1988, 432 pages, hardcover, $90, K) contains clear, non-technical explanations of astronomical concepts and many marvelous images and illustrations.

Books *are* an invaluable observing aid. Check out a few of the ones listed above. You'll find they can make your next observing session more fun as you more easily and more quickly find those formerly elusive objects. ☐

Where to find these books

Astronomical Workshop
Furman University
Greenville, NC 29613
Barron's Educational Series
250 Wireless Blvd.
Hauppauge, NY 11788
Cambridge University Press
40 West 20th Street
New York, NY 10011-4211
(800) 872-7423
Dover Publications
31 East 2nd Street
Mineola, NY 11501
Edmund Scientific Company
101 E. Gloucester Pike
Barrington, NJ 08007-1380
(609) 573-6295
Firefly Books
250 Sparks Avenue
Willowdale, ON M2H 2S4
Canada
Harmony Books
225 Park Avenue South
New York, NY 10003
Kalmbach Books
P.O. Box 1612
Waukesha, WI 53187-1612
(800) 533-6644
Royal Astronomical Society of Canada
136 Dupont Street
Toronto, ON M5R 1V2
Canada
(416) 924-7973
John Wiley and Sons
1 Wiley Drive
Somerset, NY 08875-1272
(908) 469-4400
Willmann-Bell, Inc.
P.O. Box 35025
Richmond, VA 23235
(804) 320-7016

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7" f/9 Apochromat
Only $5495

7" IN STOCK!

Meade 6" f/9 Model 152ED Refractor shown with #1697 Computer.

See the Meade ad in this magazine for full specifications and product descriptions. ED = Extremely low dispersion glass which yields color-free virtually perfect images. PPEC = Permanent Periodic Error Correction "Smart Drive."

Model 102 ED 4" f/9 Apochromat & mount (add $105 P&S)	**$2195**
Model 127 ED 5" f/9 Apochromat & mount (add $125 P&S)	**$2795**
Model 152 ED 6" f/9 Apochromat & mount (add $185 P&S)	**$4495**
Model 178 ED 7" f/9 Apochromat & mount (add $215 P&S)	**$5495**
Medium format adapters ..... Mamiya 645, **$98;** Pentax 6X7,	**$98**
Med. format EASY-GUIDER™: Mamiya 645, **$298;** Pentax 6X7,	**$298**

DRIVE SYSTEMS

#1664 Electronic Drive with PPEC & 2X, 32X slewing system	**$375**
#1697 Computer Drive, 747 object computer memory, automatic slewing to desired object	**$695**
8,000 Object CNGC Library .. **$99** Polar alignment finder ..	**$99**

OPTICAL TUBE ASSEMBLIES (OTA)

Model 102 ED/OTA 4" f/9 OTA only (add $55 P&S)	**$1045**
Model 127 ED/APO-OTA 5" f/9 OTA only (add $60 P&S) ...	**$1595**
Model 152 ED/APO-OTA 6" f/9 OTA only (add $100 P&S) ..	**$2295**
Model 178 ED/APO-OTA 7" f/9 OTA only (add $120 P&S) ..	**$3250**
Cradle ring assem. 4" (4½" OD tube) **$145;** 5" (5½" OD tube)	**$159**
Cradle ring assem. 6" (7" OD tube) **$189;** 7" (8" OD tube)	**$240**

EQUATORIAL MOUNTS

LXD 600 mount and standard field tripod (add $60 P&S) ..	**$1350**
LXD 700 mount and giant field tripod (add $100 P&S)	**$2250**

NOTE: Add the indicated packing and shipping (P&S) costs to each telescope for insured UPS shipment to your door.

MEADE SERIES 4000 PREMIUM EYEPIECES

6.4, 9.4, 12.4, 15, 20, 26mm Plossl	**$88**
32mm, 40mm Super Plossl	**$110**
56mm Super Plossl (2") ***THE BEST****	**$230**
13.8mm Super Wide Angle	**$140**
18mm Super Wide Angle	**$150**
24.5mm Super Wide Angle	**$170**
32mm Super Wide Angle (2") ...	**$240**
40mm Super Wide Angle (2") ...	**$299**
4.7mm Ultra Wide Angle	**$155**
6.7mm Ultra Wide Angle	**$188**
8.8mm Ultra Wide Angle (1¼/2")	**$230**
14mm Ultra Wide Angle (1¼/2")	**$270**

Shipping charges of 1-2% are extra.

**Plossl test, "SKY & TELESCOPE," p490-492, May 1988*

MEADE LX100 & LX200 SCHMIDT-CASSEGRAINS

8" LX200
$2295

NEW Meade 8" LX200 Telescopes

See the Meade ad in this magazine for full specifications & details. **LX100 Drive,** 2X, 32X speed control with PPEC (Permanent Periodic Error Correction "Smart Drive") & dual-axis hand controller. **LX200 Drive,** Full electronic control with PPEC, 747 object computer memory and automatic computer controlled slewing to desired object. *NOTE:* A wedge is **not** needed for visual observing with the LX200 Drive.

8" LX100 Schmidt-Cassegrain with wedge (add $105 P&S)	**$1995**
8" LX200 Schmidt-Cassegrain with computer (add $105 P&S)	**$2295**
Wedge for photographing with 8" LX200	**$110**
10" LX100 Schmidt-Cassegrain w/super wedge (add $145 P&S)	**$2695**
10" LX200 Schmidt-Cassegrain with computer (add $145 P&S)	**$2595**
Super Wedge for photography with 10" LX200	**$395**
8,000 Object CNGC Library	**$99**

OTHER SCHMIDT-CASSEGRAINS

***NEW!* SSC-8,** 8" Schmidt-Cass on LXD-600 mount (add $105 P&S)	**$1795**
***NEW!* SSC-10,** 10" Schmidt-Cass on LXD-600 mount (add $145 P&S)	**$2095**
***NEW!* SSC-12,** 12" Schmidt Cass on LXD-700 mount (add $195 P&S)	**$3850**
***NEW!* SSC-14,** 14" Schmidt-Cass on LXD-700 mount	***Avail. Summer '94***
Meade 2045D 4" f/10 with motor drive (add $40 P&S)	**$699**
Meade 2080B 8" f/10 with tripod, wedge, MCOG (add $85 P&S)	**$1149**
NEW! Model 2120B 10" f/10 w/wedge, tripod, MCOG (add $125)	**$1449**

PHOTOGRAPHY ACCESSORIES

LUMICON Cassegrain EASY-GUIDER f/6 or f/10	**$225**
LUMICON Giant EASY-GUIDER for 10" f/5-f/10 operation ...	**$395**

MEADE STARFINDERS

8" f/6
$699*

New 8" f/6 Meade Starfinder telescopes

See the Meade ad in this magazine for full descriptions and technical specifications for 6" to 16" Starfinders. These are complete telescope systems with motor drive, mount, finderscope and 25mm (=48X) eyepiece.

6" f/8 Starfinder 6(add $50 P&S)	**$599**
8" f/6 Starfinder 8 (add $60 P&S)	**$699**
10" f/4.5 Starfinder 10 (add $75 P&S)	**$799**
16" f/4.5 Starfinder 16 (ship. freight COD) .	**$2195**

*All Starfinder telescopes shipped directly from Meade to the purchaser. Please add the indicated shipping charge to the price. LUMICON showroom prices are $96 higher.

ACCESSORIES

LUMICON carries the full line of Meade accessories. See the Meade ad in this magazine for detailed prices and descriptions.

Meade #43 Single axis drive corrector	**$99**
LUMICON DX200 Dual-axis drive cor.	**$249**
Meade 47M Dual-axis drive corrector	**$450**
LUMICON DX2BP Dual-axis drive corrector with built-in battery pack	**$299**

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Higher Performance — Lower Price

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LOW PRICE—from $399

LUMICON SKY VECTOR FEATURES:

- "GUIDE" mode leads you to object
- Digital right ascension readout to 1 min.
- Digital decl. readout to 10 arc-min.
- 4000 pulse (0.09° accuracy) encoders
- Polar alignment ***not required!***
- Motor drive ***not required!***
- Just sight two stars to align!
- Works **equally well** for alt-azimuth telescopes like Coulter Odyssey and equatorial mounts like C-8, Meade 2080.
- **No need** to enter latitude, longitude, etc.

SKY VECTOR I™ $399

NEW! With over 220 object memory including the 110 Messier and 58 best NGC objects.

SKY VECTOR II™ $499

IMPROVED — Planets, Over 3,700 Objects! With size, magnitude and full visual description.

NGC SKY VECTOR™ $699

IMPROVED!—5500 Additions / Corrections

NGC-Sky Vector™
OFF ON
DIM
MODE
ENTER
UP
DOWN
LUMICON®

Improved NGC SKY VECTOR with over 12,000 object memory including the planets, complete, corrected RNGC catalogue, IC catalogue, P&K planetary catalogue, & much more!

Specify Telescope Type: Meade 2045, 2080, 2120, C-8, C-11, Odyssey 8, 10, 13, 17½, Alt-Azimuth.

Ultima 8, 11 .. **add $25**, C-14 .. **add $75**

COMA CORRECTOR

Coma 1 inch off-axis 17½" f/4.5

Same field with LUMICON coma corrector; smaller, more numerous stars.

This computer-designed LUMICON 2" lens reduces coma and flattens the field for both viewing and photography. **It threads into LUMICON 2" EASY-GUIDERS for effortless installation.** This zero power lens does not change image scale nor shift focus, and all lens surfaces are multi-coated for highest efficiency. Clear aperture = 1.8".

LUMICON 48mm Coma Corrector/Field . Flattener Lens	**$285.00**
LUMICON 2" EASY-GUIDER .	**$169.50**
2" EASY-GUIDER (Mamiya 645)	**$199.50**
2" Adapter for Pentax 6x7	**$129.00**
2" Adapter for Hasselblad .	**$229.00**
2" Adapter for Bronica SQ-A	**$175.00**
2" Extension for viewing ...	**$26.00**

2" DELUXE BARLOW

1.8x Multiplier Lens (2" Barlow)

LUMICON 1.8x Multiplier Lens (2" Barlow)	**$235.00**

LARGE UV/DUST SEAL

Protect the optics of your 8-14" Schmidt-Cassegrain with a UV/Dust Seal. Simply thread it onto the rear cell, then attach all normal accessories. The large size fits Meade 2120, Celestron-11 and -14 & has a high quality multi coated (removable) 72mm UV filter.

Deep-Sky Filter/Dust Seal for C-8, 2080 ...	**$119.50**
UV/Dust Deal for Celestron C-8 ...	**$39.00**
UV/Dust Seal for Meade 2080, 2045	**$39.00**
UV/Dust Seal (large) for Meade 2120	**$89.50**
UV/Dust Seal for Celestron-11, -14 .	**$89.50**

NEW! LOW PROFILE HELICAL FOCUSERS

FROM $59.50

LUMICON® LOW PROFILE FOCUSERS

LUMICON now offers 3 different low-profile helical focusers. They stand only 1¼-1½" above the telescope tube. Use the 1¼" or 2" versions for viewing. Use the 2" non-rotating focuser for convenient photography with the LUMICON 2" EASY-GUIDER™.

Select your desired base-plate shape! Flat, 7" OD, 9½" OD, 12½" OD, 16" OD, 21" OD.

LUMICON 1¼" Helical Focuser	**$59.50**
LUMICON 2" Helical Focuser 1½" high	**$65.00**
LUMICON Non-rotating Helical Focuser	**$129.00**
2" Astro Systems focuser, only 2" high	**$139.00**
3 handles for non-rotating focuser	**$12.95**
2"/1¼" adapter w/48mm filter threads	**$20.00**
2" LUMICON EASY-GUIDER	**$169.50**

LUMICON 50mm, 80mm SUPER-FINDER™

Visual Astronomers prefer the LUMICON 80mm SUPER-FINDER™, since hundreds of deep-sky objects, including most Messier objects, are visible directly. SUPER-FINDERS also make nice small portable telescopes. 80mm aperture, F=300mm coated achromat or 50mm, F=200mm coated achromat. Eyepieces and/or star diagonal are extra.

1¼" 50mm Finderscope **$59.50**, right-angle	**$59.50**
1¼" straight-thru 80mm SUPER-FINDER ...	**$169**
1¼" right-angle 80mm SUPER-FINDER ..	**$179.50**
1¼" right-angle version, w/star diagonal	**$209**
25mm Cross-hair 1¼" eyepiece (12X)	**$39**
Large mounting rings for 80mm Finder	**$55**
1¼" Star Diagonal **$39**, Mounting Brackets,	**$39.50**
1¼" 45° diagonal for correct left-right views	**$52.44**

LOTS OF ADAPTERS

2" adapter for C-8, Meade 2080, etc. ..	**$26.00**
2" adapter for C-80, C-100 refractor ...	**$39.50**
2" adapter for C-70, C-80F, C-100F fluorite	**$39.50**
2" adapter for C-6, Comet Catcher, Meade 312	**$30.00**

EXTENSION TUBES

1" long 1¼" OD thread-in extension ...	**12.00**
2½" long extension (holds 1¼" filters) .	**16.00**
4½" long extension for 1¼" eyepieces	**$25.00**
3" long extension for 2" eyepieces* ..	**$26.00**
2" long extension for 2" eyepieces* ..	**$26.00**

VIEWING ADAPTERS

2"/1¼" reducing bushing, threaded 48mm*	**$20.00**
2"/T-thread adapter, threaded 48mm* ..	**$25.00**
T-thread/1¼" adapter	**$25.00**
F/10 2" or 1¼" eyepiece viewing adapter for Giant Easy-Guider	**$39.50**
Low profile star diagonal eyepiece holder	**$16.00**
Meade 2" Diagonal/Giant Easy-Guider	**$39.50**

**Threaded to hold 48mm filters.*

Meade & Celestron
LUMICON Carries a full line of telescopes & accessories. Fast Delivery, competitive prices.

LUMICON FOR HIGH PERFORMANCE

ASTROPHOTO OF THE MONTH

M-16, The Eagle Nebula, in Serpens. 45 minute photo by Tony Hallas and Daphne Mount using a 14" SCT and a LUMICON Giant Easy-Guider at f/7.5 with hypered TP 2415 film. "**If it wasn't for your accessories, these astrophotos wouldn't be possible,**" said Tony. M-16 is seen best with a LUMICON UHC Filter, and photographed best in color with a LUMICON Deep-Sky Filter.

"I'd Pick The TELE VUE™"

40mm Wide-Field Test, "Astronomy," Aug. 1990, p. 90

Genesis 4" f/5 4 element fluorite	$1595
Pronto 70mm f/6.4 apochromat w/2" diagonal	$798
Pronto 70mm f/6.4 w/45° erecting prism	$698
Complete Equatorial Mount	$795
Motor Drive for above mount	$239
7.4, 10.4, 13, 17, 21, 26mm Plossl 50°	$79
1.8x or 2.5x Tele Vue Barlow Lens	$89
2" Giant Barlow - 2x	$189
32mm Plossl, widest true field in 1¼"	$109
55mm 2" Plossl, widest possible field	$219
15mm Wide-Field, 1¼" eyepiece, 65°	$135
19mm Wide-Field, 1¼" eyepiece, 65°	$145
24mm Wide-Field, "Rich-Field!" 65°	$169
32mm Wide-Field, 2" eyepiece, 65°	$239
40mm Wide-Field, "Rich-Field!" 65°	$299
4.8mm Nagler, 82° field, 1¼" eyepiece	$149
7mm Nagler, 1¼" eyepiece, 82° field	$189
9mm Nagler, 82° field, 1¼" or 2"	$219
11mm Nagler, 82° field, 1¼" or 2"	$235
13mm Nagler, 82° field, 1¼" or 2"	$249
12mm Nagler, Type II, 82°, 1¼"/2"	$249
16mm Nagler, Type II, 82°, 1¼"/2"	$289
20mm Nagler, Type II, 82°, 2" only	$340
1¼" Paracorr Visual Coma Corrector	$159
2" Paracorr Visual Coma Corrector	$249
NEW! 22mm Panoptic 1¼"/2", 68°	$249
NEW! 35mm Panoptic 2", 68° field	$325

ADJUSTABLE PIGGYBACK MOUNT

The LUMICON adjustable piggyback mount is ideal for telescopes of 6-16" aperture. It permits **both** vertical and sideways adjustment for optical alignment. Also ideal to mount LUMICON 80mm SUPER-FINDER™, large telephoto lenses and small telescopes up to about 5 lbs.

LUMICON Adjust. Piggyback Mount $59.50
Specify telescope size: 6", 8", 10", 11", 14", 16"

H-ALPHA PASS FILTER

Yields spectacular contrast gains in B&W photograph with telephoto lenses. Yields pinpoint star images. Superb with hypered 2415. For color, use the Minus Violet (MV) Filter.

Specify Lens Size	H-Alpha	(MV)
46, 48, 49mm	$49.00	$39.00
52, 55, 58, 62mm	$59.00	$49.00
67, 72, 77mm	$69.00	$59.00
82mm	$79.00	N/A

Hypered 2415 film, 36 exp ... **$10.95, $3/$29**

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NEW! ENHANCED ALUMINUM DIAGONAL MIRRORS BOOST TELESCOPE PERFORMANCE

LUMICON 1.3" & 2.1" enhanced aluminum diagonal mirrors & 1¼" star diagonal.

The new LUMICON diagonal mirrors have a special enhanced aluminum coating with a protective overcoating for long life. Visible reflectivity is 94-96% compared to 86-89% for standard aluminum coated mirrors. The extra 5-10% transmission is like adding up to an inch of aperture! The substrate is fine annealed Pyrex flat to 1/8 wave.

1.32"	**$39.50**	1.52"	**$45.00**	1.83"	**$49.50**
2.14"	**$59.50**	2.60"	**$75.00**	3.10"	**$99.50**

ENHANCED ALUMINUM STAR DIAGONAL

90° star diagonals with 96% reflectivity enhanced aluminum mirrors in a CNC machined black anodized aluminum body. Performance far exceeds prism diagonals.

1¼" (1.32" mirror)	$99.50
2" (1.83" mirror)(see photo above)	$159.00

LUMICON FILTERS — BEST IN THE WORLD!

"The LUMICON OIII proved to be our favorite... It gave the greatest contrast gain."
ASTRONOMY February 1991

AMAZING OIII FILTER™

Helix Nebula, NGC 7293 in Aquarius. Bright and easy with Lumicon Oxygen-III Filter.

The ultimate in filter performance! The Lumicon Oxygen-III Filter has a contrast twice as high as the high performance Lumicon UHC Filter™. Use the Oxygen-III Filter for observing the very faintest planetary and diffuse emission nebulae. Also gives incredible views of bright nebulae (like M-27, M-17, etc.) from urban locations. Bandpass is 11nm, transmission is 90-96% for both O-III lines at 496nm and 501nm.

SEE THE HORSEHEAD!

Horsehead Nebula in Orion. This faint nebula is seen best with a LUMICON H-Beta Filter. Photo by J. Marling using a Deep-Sky Filter.

"I CAN SEE THE VEIL NEBULA!"

Rich Zepernick saw the Veil Nebula for the very first time with a **LUMICON UHC Filter**. He stated, *"It was actually there! and not just around 52 Cygni, but the whole loop! Words cannot possibly express my feelings. I don't know how I managed without these filters."*

Rich Zepernick, Cresskill, NJ

DEEP-SKY FILTER™

BEST for Astrophotography!

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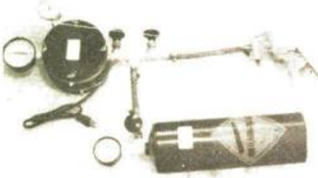

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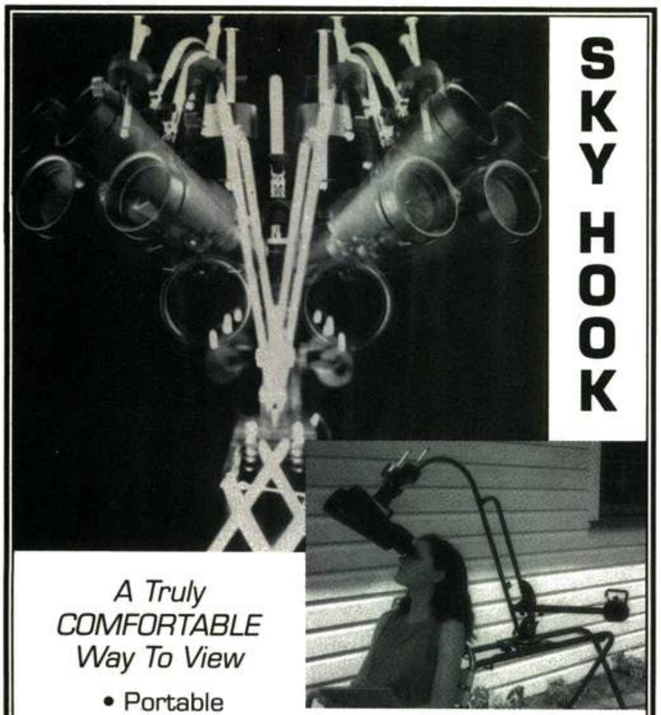

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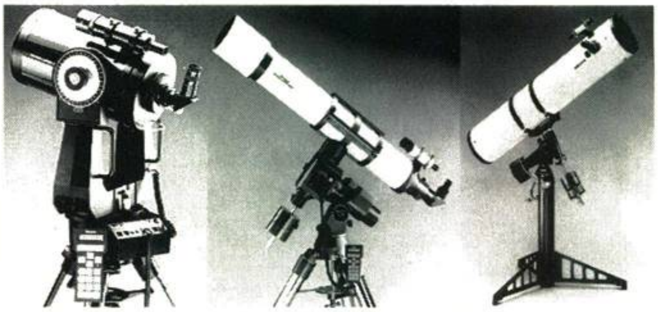

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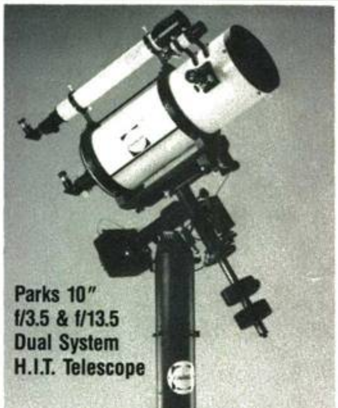

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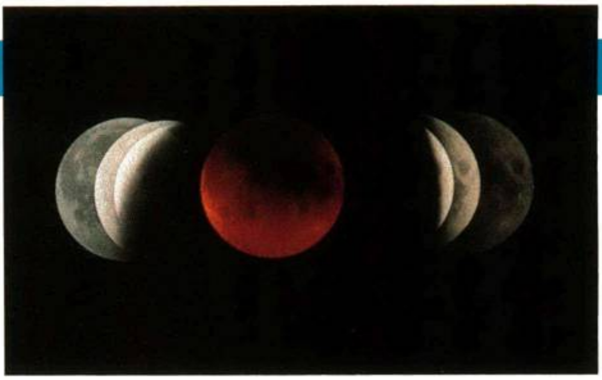


Two magnificent eclipses spaced just two weeks apart last spring allowed observers in the Americas, northern Europe, and eastern Asia to see celestial shadow-play. The Moon edged across the Sun during the partial solar eclipse on May 21, 1993, and Earth's shadow swept across the Moon during the total lunar eclipse of June 4. For North American observers, the lunar eclipse occurred near moonset and the solar eclipse near sunrise.

Barney Magrath of Waimea, Hawaii, observed the lunar eclipse from Mauna Kea. When the Moon entered the penumbra at 12:11 a.m., Magrath at first did not notice a darkening on the lunar surface. "An hour later," he says, "I could tell the eclipse would be very dark because I could no longer see detail in the umbra." The Moon darkened considerably as it neared mid-eclipse. "The Moon's disk had a very dark ashen hue," says Magrath. "I could not see any detail on the lunar disk even through a telescope. It was weird."

From Auckland, New Zealand, Joe Myers described his first total lunar eclipse experience as a surprise. "Despite the indications that the Moon might be quite dark, the luminosity variation floored me," he says. "At mid-eclipse I peeked through my 60mm guidescope and could not see anything of the Moon — it was gone."

In Whyalla, South Australia, high school students in Paul Billows' science class collectively described their eclipse experience. Lab assistant Mark Harrison and students Grant Smith, Martin Cayetano, Chris Fosteris, Sarah Ettridge, Melissa Schultze, and Heidi Hamilton described the entrancing part of the experience, the "ruby red color of the Moon."

The disappearance of the Moon struck Robert A. Donner of Goleta, California. "At 5:15 a.m. the Moon was a small coppery arc suspended above the ocean," says Donner. "Two minutes later I couldn't see it through a 10-inch reflector." Californians John M. Burton and Grace Reeh watched the eclipse from the Palos Verdes Peninsula and saw a "tiny, diffuse sliver of Moon surrounded by a hazy, blue-gray sky. The eclipse ended for us before totality as clouds rolled in."

The solar eclipse also attracted enthusiastic skywatchers. On May 21 Ernie Piini of San Jose drove up Mount Hamilton and set up his equipment about one mile east of Lick Observatory. Although the weather looked promising throughout the early morning hours, shortly before sunrise clouds formed. "We saw the eclipse, barely, and we watched the Sun through various densities of fog and cloud," says Piini.

Farther east, in Longmont, Colorado, Michael J. Hutchinson watched the Sun move out of clouds and into a clear sky shortly after it rose. "I enjoyed seeing the lunar mountains highlighted by the Sun through my 80mm spotting scope," says Hutchinson.

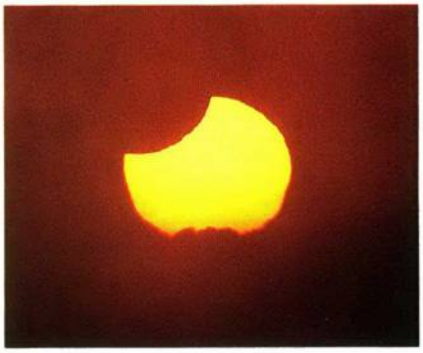
Mick Deckman of Parker City, Indiana, watched the eclipse from the extreme southern limit of the Moon's shadow path. "After the sky cleared following sunrise I waited for evidence of the eclipse, and a small dent nicked the Sun," says Deckman. "I ran for my wife so she could witness the eclipse — it was great!"

Pluto Sightings. Following the article "Pluto Watch" (May 1993), we continue to receive accounts from victorious observers who have spotted the ninth planet. From Bob Shindorf of Traverse City, Michigan: "I am pleased to report sighting Pluto on June 21, 1993, using a 13.1-inch reflector, exactly where your finder chart showed it to be." Shindorf spent four nights at the eyepiece searching for Pluto, the first two identifying the starfield and the third and fourth sketching it. "On the fourth night I knew I'd found it," he says. "It's exhilarating. I can't believe how faint it is."

Frank Kraljic Jr., of Scottsdale, Arizona, spotted the elusive Pluto with his 20-inch f/4 reflector at 117x, and made meticulous sketches over several nights to identify the faint planet.

Messier's Mistake. Fourteen-year-old amateur Ted Stryk of Bristol, Virginia, alerts observers to "Messier's observable error." In compiling his famous catalog of nebulous objects, the French comet hunter included M40, a pair of magnitude 9.0 and 9.3 stars separated by 50" and lying in Ursa Major. Apparently the stars looked fuzzy when Messier logged his observation.

"When I observed M40," Stryk says, "it appeared as two faint stars, one slightly brighter than the other, in an uncluttered field. I failed to see any color, but the view is still a good one." Despite the error made by Messier, suggests Stryk, M40 is a double star enthusiasts should not overlook. ☐



THE MOON AND SUN MET last spring when observers witnessed both a total lunar and a partial solar eclipse. The lunar eclipse on June 4 (top and center) was visible from the western Americas, the Pacific, and eastern Asia. The solar eclipse on May 21 (bottom) could be seen from North America, northern Europe, and Asia. Photos by Lin Ben Chu (top), Joe Myers (center), and Ernie Piini (bottom).

ASTRONOMY wants to hear about your observations of the sky. Please send reports, sketches, and photographs to David J. Eicher, Reader Reports Editor, ASTRONOMY P.O. Box 1612, Waukesha, WI 53187.

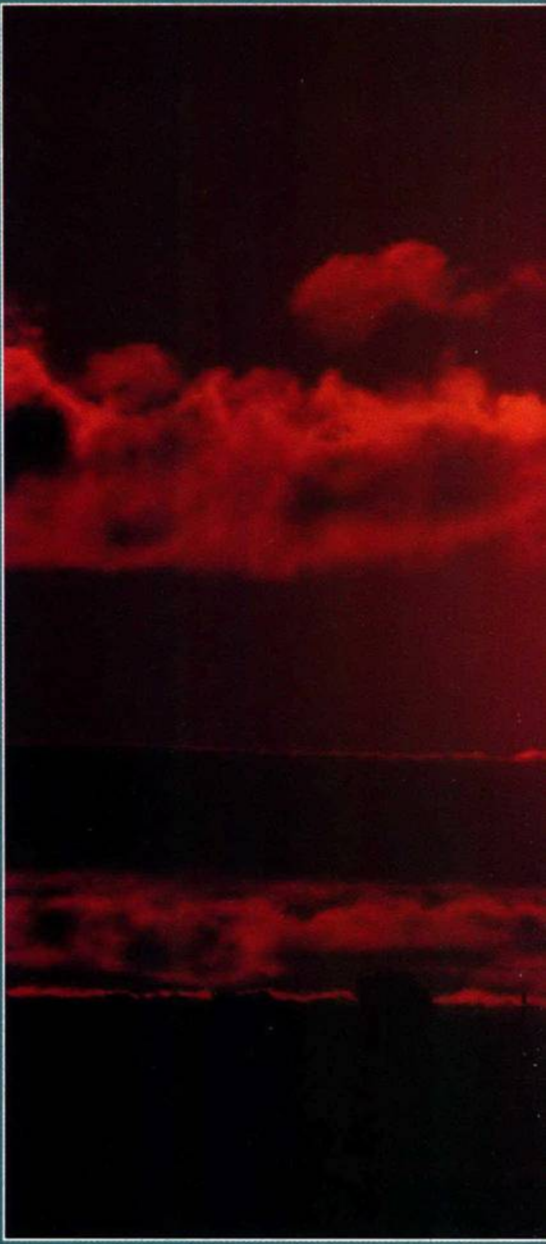
GOOD MORNING STARSHINE

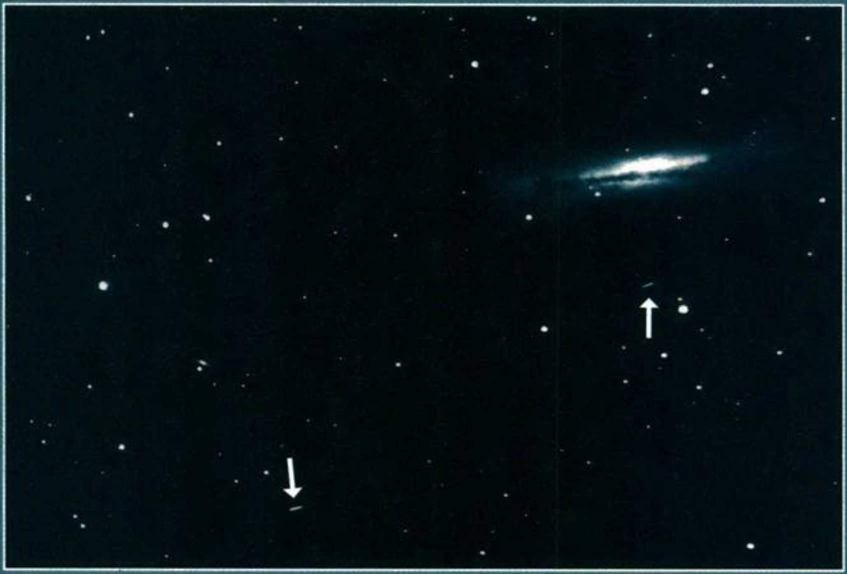
Brilliant and boiling due to atmospheric turbulence, the Sun rose on the morning of May 21, 1993, partly blocked by the Moon's disk. The eclipse was first visible in the western United States and thereafter parts of Canada, Greenland, and northern Europe. Paul Moeller's photo of the rising Sun (right) wins this month's $100 "Best Astrophoto" award. Moeller recorded the event from Goldendale, Washington, using a 5.6-inch refractor at f/7, Ektar 25 film, and a 1/1000-second exposure.

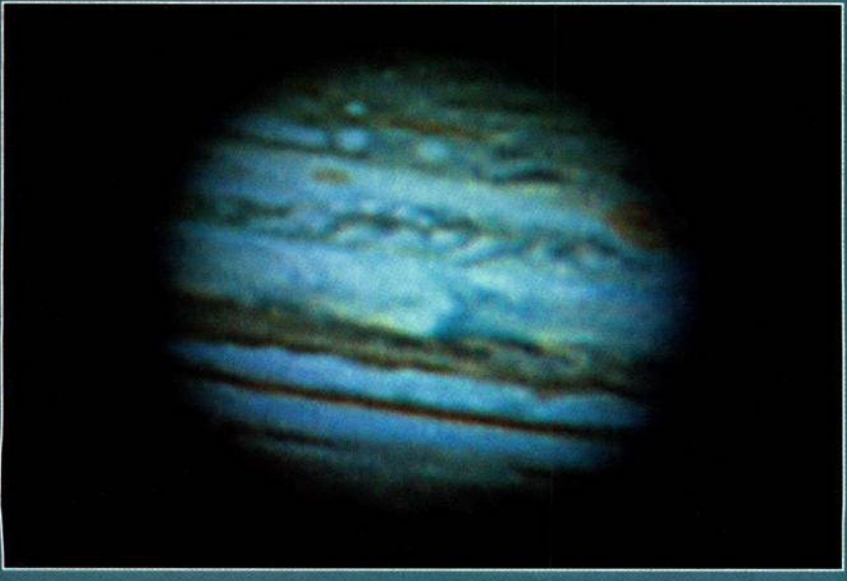
Many other astrophotographers submitted solar eclipse images. Henry Walker's photo shows the early morning view from La Mesa, California (bottom right), and Jacques Guertin's photo records the scene from Newark, California (opposite page, bottom).

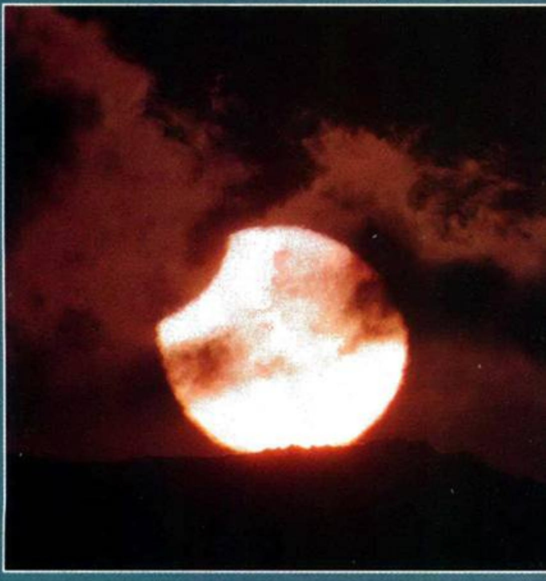
Throughout the spring and early summer, Jupiter's South Equatorial Belt erupted with detail. This included a "little red spot" in addition to the Great Red Spot. Florida astronomer Don Parker's CCD image of Jupiter on May 15 shows the little red spot along the same latitude as its big brother and near the planet's left-hand limb (bottom).

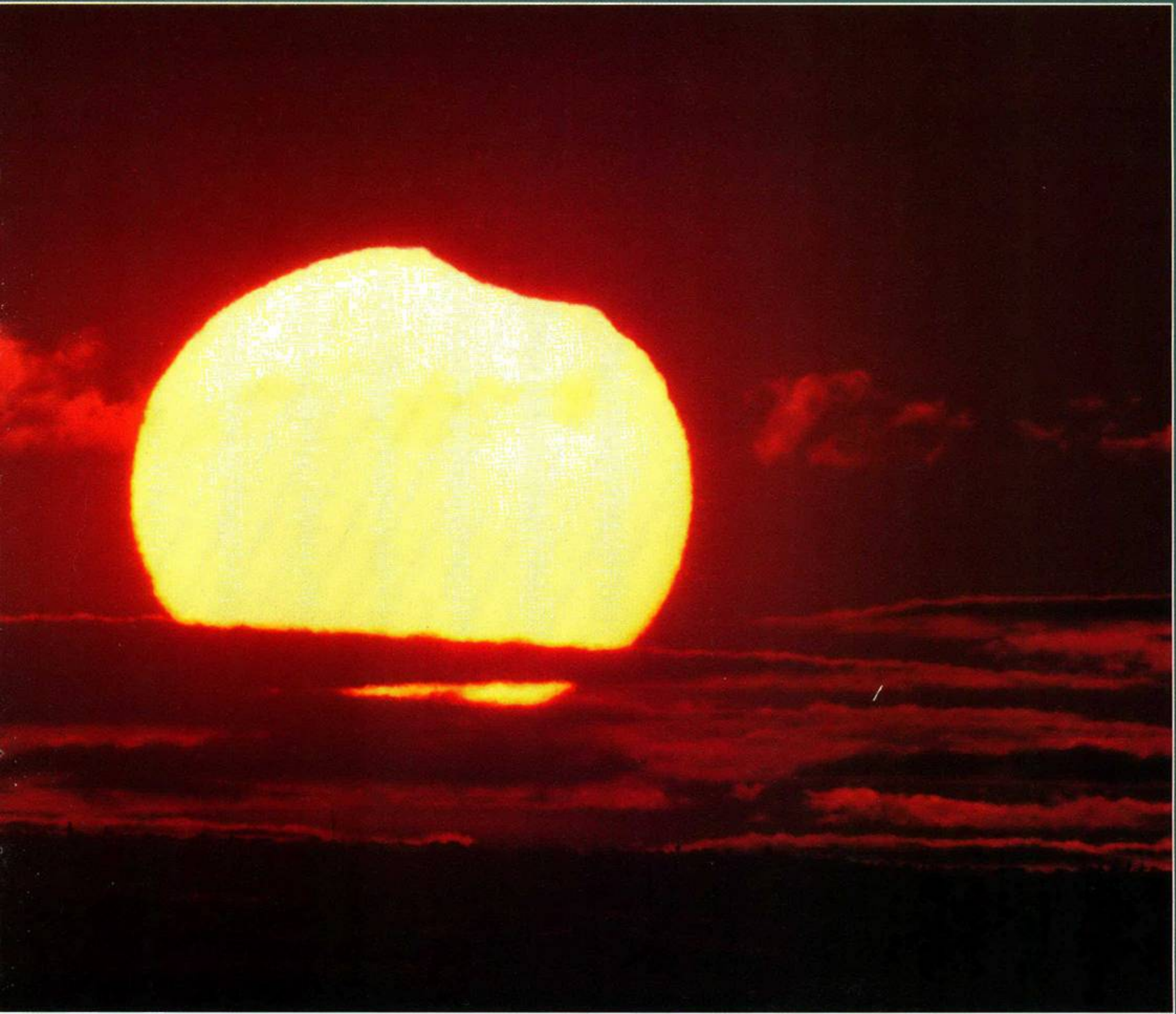
Ken Williams of Lake Clear, New York, captured the passage of two faint solar system objects past the distant galaxy NGC 3628 in Leo (below). Taken on March 25, 1993, the image shows the streaks of asteroids 394 Arduina (left) and 1385 Gelria in addition to the galaxy.











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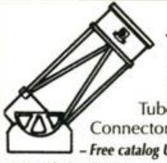

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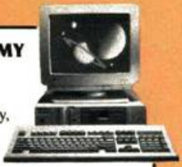

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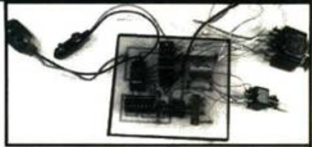

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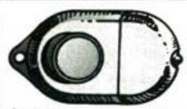

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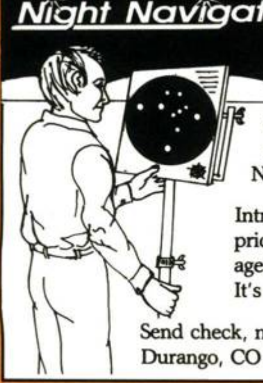

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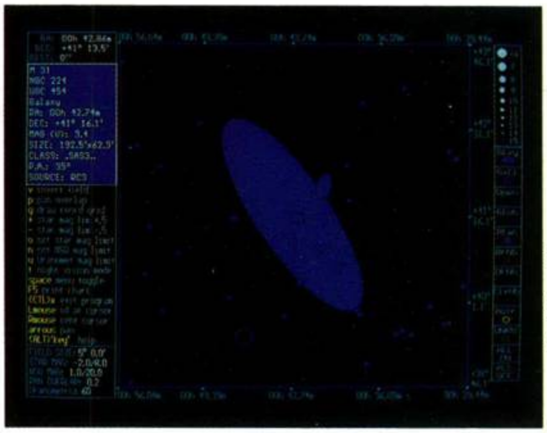

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SIZE: 192.5'x62.5'
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***MegaStar* (version 1.51)**, *E.L.B. Software, 8910 Willow Meadow, Houston, TX 77031, (713) 541-9723. Price: $139 ($149 for $3^1/2$" disks), plus shipping. Minimum requirements: 80286-based computer, 640 KB of memory, VGA display, and a hard drive with 6 MB free (an additional 48 MB needed for entire Hubble Guide Star Catalog database). A mouse and math coprocessor are recommended. MegaStar supports Epson-compatible 9- and 24-pin dot-matrix and HP LaserJet IIP-compatible printers.*

WOW! MegaStar takes deep-sky observing to new heights — over 80,000 deep-sky objects (including 66,484 galaxies) from more than 100 catalogs and over 15 million stars down to magnitude 15.5 in some regions. If the number of objects available isn't enough to impress you, perhaps the fact that it's the first program to show both the sizes of objects *and* the orientations of galaxies will.

MegaStar won't list star names or show you eclipses, comet orbits, the positions of planets, or constellation lines and boundaries. It will show you open and globular star clusters, bright and dark nebulae, planetary nebulae, galaxies, and galaxy clusters galore.

If you don't have 54 MB of disk space to spare, you can load just part of the *Guide Star Catalog*. A separate utility program lets you add and delete catalog sections any time you want.

You can show fields ranging in size from 30 arcseconds to 20 degrees and display the names of all the deep-sky objects. Finding a particular object is easy — and fast! — with the search feature. You can also add to the object database (it will automatically precess 1950.0 coordinates) and modify information about any object in the database. The sky map legend identifies the corresponding *Uranometria 2000.0* chart.

Many features let you customize maps. If you use the computer directly at your scope, you can set the screen to a red night-vision mode. An eyepiece view lets you display the field shown by your scope and eyepiece. Too many stars in the field? You can set both the bright and faint magnitude limits of stars displayed. Or you can "shrink" the star sizes. Normally the dot diameters represent the stars' magnitudes, but shrinking the stars makes them a uniform small size that prevents the stars from overwhelming the deep-sky objects — a nice feature, especially in crowded Milky Way starfields.

You can print functional finder charts with MegaStar but it uses a screen dump, so the pixelated maps may not be aesthetically pleasing. Because the simple projection used distorts maps near the poles, the program presently does not map areas within 10 degrees of the poles. Deep-sky objects appear on a map only if their centers lie within the boundary. Emil Bonanno, the originator of MegaStar, knows about these program bugs and will fix them in future versions.

MegaStar is probably the best computerized deep-sky atlas on the market, if for no other reason than the huge number of objects that come standard with the program. It's inexpensive considering the size and content of the database. The program is easy to use and has many features, like the eyepiece view, that address the needs of avid deep-sky observers. And if you are such an observer, you'll want MegaStar. — *Dave Bruning*

Where in Space Is Carmen Sandiego? Deluxe, *Brøderbund Software, P.O. Box 6121, Novato, CA 94948-6121, (800) 521-6263. Price: $79.95. Minimum requirements: 80386-based computer, 640 KB of memory, DOS 3.1, mouse, VGA display, and a hard drive with 8 MB free. Recommended for ages 12 and up.*

Carmen Sandiego and her V.I.L.E. gang of 14 alien outlaws have stolen the shepherd satellites from Saturn's rings — and lots of other things. It's your job to track down the criminals and arrest them. You'll visit the Sun and more than 30 planets and satellites in search of the thieves. That's no simple task because they might hide in Con crater or in Marius Regio.

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You also have the most modern of computers to help you, the VAL 9000, which contains many useful databases. A clue may tell you that a henchman's favorite astronomer received an award from the King of Denmark for discovering a comet. VAL will help you learn that this was Maria Mitchell. It will also steer you to Ganymede, Jupiter's satellite, for Marius Regio (in case you were wondering).

Certainly Where in Space . . . is entertaining. You might question whether this program has educational value. After all, is it really important to know that Con crater is on Rhea? That's trivia, not an essential piece of knowledge about our solar system. And a few truths are stretched in order to give short, snappy clues. However, it does package many important astronomical facts in a format that is appealing to kids and many adults. And who knows? Maybe a clue like the one about Marius Regio will stimulate someone to find out that this feature was named after Simon Marius, who co-discovered and named the four largest moons of Jupiter — and thereby launch a lifelong interest in astronomy. Maybe Carmen isn't such a bad character after all.
— *Dave Bruning*

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***ST6PIX,** Richard Berry, RR 1, Box 58A, Cedar Grove, WI 53013, (414) 285-3305. Price: $49.95, plus $2.90 for shipping. Minimum requirements: IBM PC-compatible computer and VGA display. A math coprocessor is recommended.*

Owners of Santa Barbara Instrument Group's ST-6 CCD camera can use this program to process individual images or batch process a series of images. You can invoke separate functions or use the program's automatic feature that produces optimally processed images. ST6PIX will scale, filter, mask, and sharpen your images, saving the finished product in either the ST6 or TIFF formats. ☐

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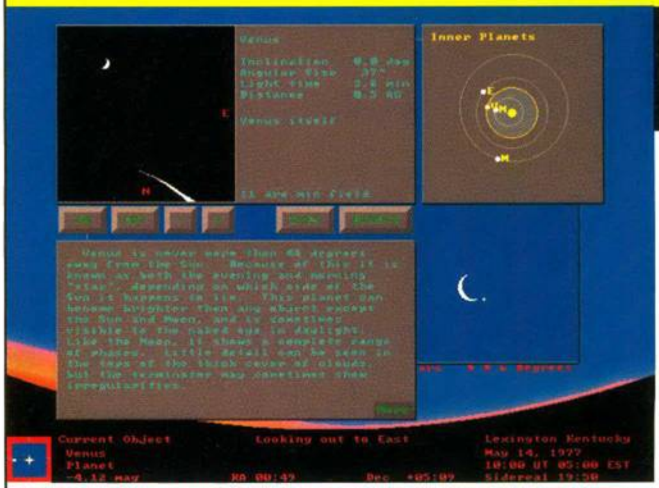

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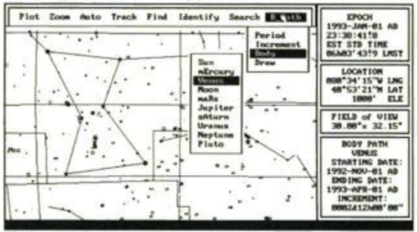

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OBSERVING THE MOON

The Moon: An Observing Guide for Backyard Telescopes, by Michael T. Kitt, (Kalmbach Books, 1992), ISBN 0-913135-09-7, 80 pages, softcover, $11.95.

If you're looking for a good lunar observing guide, consider *The Moon* by Michael Kitt. This well-written book has something for everyone, from beginning to seasoned observers.

The book contains three sections, opening with one on how to observe the Moon. The second section covers lunar history, which provides the reader with an understanding of the origin of lunar features. The final section, which comprises the majority of the book, takes you on a guided tour of some 250 lunar features grouped in 14 regions. You can see almost all of these features through a 4-inch refractor or 6-inch reflector.

Kitt's style is easy to read and his first-hand experience as an observer is evident. But this is not the kind of book you want to read in one sitting. I recommend covering a section at a time, preferably before going out to observe the features described in that section.

The book contains a pleasant balance between professional and amateur photographs. The photos are superb, but the glossy paper on which they are printed shows fingerprints and smudges, which are difficult to remove.

The photos show south up because, as the author states, this orientation matches the view seen through the telescope. But this isn't true if you use a diagonal prism on a refractor or Schmidt-Cassegrain. Also in a couple of instances, the author designates the location of certain features using the analogous position on a clock face with north corresponding to twelve o'clock. So to compare his description to the north-at-bottom photos, you need to turn the clock or the book upside down to circumvent this nuisance.

While every two-page spread has at least one picture or drawing, I would have liked to see more photos. Many of the features described in the text are not illustrated. In fairness, the author does say that you need a good lunar map to locate most of the features mentioned. In addition, several pages often separate the text and illustrations about a feature or region. Furthermore, the photos should contain labels to make identification of the features easier, especially on the wide-field photos.

Aside from these few minor complaints, the book is excellent overall. Regardless of your lunar observing experience, you will find *The Moon* a useful addition to your astronomy library. — *Mark J. Coco*

Space

Space Age, by William J. Walter, (Random House, 1992), ISBN 0-679-40295-0, 333 pages, hardcover, $30.

If you didn't see "Space Age" on Public Television, you can still read this companion volume to the series. Walter describes the beginning of space exploration, starting with Konstantin Tsiolkovsky and Robert Goddard's early rocketry ideas around the turn of the 20th century. He follows human fascination with the Red Planet and describes what future missions to Mars might be and what explorers might find. *Space Age* also discusses the present "Mission to Earth," NASA's program that uses satellites to better understand Earth's climate and geology, and future missions to the Moon.

The Art of Robert McCall, by Robert McCall, captions by Tappan King, (Bantam Books, 1992), ISBN 0-553-07355-9, 150 pages, hardcover, $60.

Over 75 of the eminent space artist's paintings and murals are reproduced in this 11.5" by 11.5" book. The art works include a painting of a solar sail spacecraft envisioned in 1960, poster art for the 1968 movie "2001: A Space Odyssey," several murals at Disney's EPCOT Center in Florida, and fanciful works showing cities in clouds and cosmic landscapes.

Men and Women of Space, by Douglas B. Hawthorne, (Univelt, Inc., 1992), ISBN 0-912183-08-X, 904 pages, hardcover, $90.

Hawthorne provides biographies in alphabetical order for some 650 astronauts and cosmonauts. Appendices list these space travelers by country and selection date. An additional appendix lists all spaceflights and crews from Vostok 1 (April 12, 1961) through STS-45 (space shuttle Atlantis, March 24-April 2, 1992).

Comets

Catalogue of Cometary Orbits, 1993, by Brian G. Marsden and Gareth V.

Williams, (Minor Planet Center, Smithsonian Astrophysical Observatory, 60 Garden Street, Cambridge, MA 02138), 102 pages, softcover, $20.

The 1993 *Catalogue* contains the orbital elements for 1,392 comets and a list of the intervals during which the comets were observed. It also provides a correspondence between provisional designations, given when comets are first observed, and Roman numeral designations that list comets in order of closest passage by the Sun (for example, 1977n became 1978 XVII).

CCD Imaging

Deep Space CCD Atlas: North, by John C. Vickers, (Back River Observatory, P.O. Box 1292, Duxbury, MA 02331, 1992), 262 pages, softcover, $27.50 plus $2.50 shipping.

Vickers presents roughly 2,300 images of deep-sky objects taken with a 14-inch Schmidt-Cassegrain and a Photometrics Star 1A CCD camera. The objects include over 1,600 galaxies, more than 400 star clusters, 120 planetary nebulae, and other objects. The atlas shows black stars on a white sky and goes as faint as 21st magnitude.

Astronomical CCD Observing and Reduction Techniques, edited by Steve B. Howell, (Astronomical Society of the Pacific, 1992), ISBN 0-937707-42-4, 329 pages, hardcover, $44.50.

These printed lectures from the "School on Charge Coupled Devices" held in Tucson, Arizona, in 1991 contain considerable information about using CCDs and reducing data obtained with these electronic detectors. Backyard astronomers who already use CCDs but want to know more about getting the most from their images will find this book helpful. The lectures also describe how to use CCDs for planetary observations and measuring the positions and brightnesses of objects.

Other Books Received

Robotic Telescopes in the 1990s, edited by Alexei V. Filippenko, (Astronomical Society of the Pacific, 1992), ISBN 0-937707-53-8, 367 pages, hardcover, $44.50.

Proceedings from a meeting concerning automatic telescopes, scientific results and imaging obtained from these scopes, and ideas for future robotic scopes on the Moon. □

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GLASS - *TYPE 1* *(Full Aperture)*

Made from high quality hand select glass, machine polished and TRIPLE COATED with a Nickel-Chromium alloy (same as Inconel). Mounted in a machined aluminum cell ready to attach to telescope. Solar image is yellow-orange. No secondary filtering is necessary.

Aperture	Mounted	Aperture	Unmounted
2.4"	$49.00	2.4"	$39.00
3.1"	52.00	3.1"	42.00
3.5" to 4"	59.00	3.5 to 4"	49.00
4-1/4" to 5"	74.00	4-1/4" to 5"	64.00
6"	79.00	6"	69.00
8"	95.00	8"	85.00
10"	109.00	10"	99.00
11"	119.00	11"	109.00
12.5" to 13.1"	149.00	12.5" to 13.1"	129.00
14"	169.00	14"	149.00

40mm to 80mm Binoculars - Mounted .... $92.00 pr.

GLASS - *TYPE 2* *(Full Aperture)*

Same as type 1, except stainless steel is combined in the coating to provide an even more durable surface that highly resists wear due to excessive handling and ultraviolet radiation. Solar image is also yellow-orange.

Aperture	Mounted	Aperture	Unmounted
2.4"	$62.00	2.4"	$52.00
3.1"	65.00	3.1"	55.00
3.5" to 4"	76.00	3.5 to 4"	66.00
4-1/4" to 5"	96.00	4-1/4" to 5"	86.00
6"	105.00	6"	95.00
8"	125.00	8"	109.00
10"	139.00	10"	119.00
11"	149.00	11"	139.00
12.5" to 13.1"	179.00	12.5" to 13.1"	159.00
14"	199.00	14"	179.00

40mm to 80mm Binoculars - Mounted .... $115.00 pr.

GLASS - *TYPE 3* *(Full Aperture)*

Coated to a neutral density of 4 for serious astrophotographers who desire the shortest possible shutter speeds with slow films. Solar image and optical quality same as type 1 & type 2. Type 3 filters are for photographic use only.

Aperture	Mounted	Aperture	Unmounted
2.4"	$79.00	2.4"	$65.00
3.1"	82.00	3.1"	69.00
3.5" to 4"	99.00	3.5 to 4"	79.00
4-1/4" to 5"	125.00	4-1/4" to 5"	110.00
6"	135.00	6"	115.00
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Mylar and plastic viewers are coated to a neutral density of 5. Transmission in visual light is approximately 1/1,000th of one percent. There is no significant transmission in ultraviolet or infrared. Designed for naked eye visual use.

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New Astronomy Products

1 Celestron Introduces New 8-inch SCTs

Celestron's C8$^+$ comes on a traditional fork mount with built-in DC drive and drive corrector electronics powered by an internal 9-volt battery. The drive uses a re-engineered spur-gear mechanism. The C8$^+$ comes with an aluminum tripod, 6x30 finder, 1.25-inch star diagonal, and 25mm Orthoscopic eyepiece. The C8$^+$ Computerized (top) offers the same features but includes an Advanced Astro Master computer and shaft encoders that can guide users to any of the more than 8,000 objects in the computer's database.

The Great Polaris C8 (bottom) replaces the popular Super Polaris C8. The new German equatorial mount features improved stability, slow-motion controls, and latitude adjustments. Standard features include Starbright coatings, wood tripod, 6x30 finder, piggyback mount, 1.25-inch star diagonal, and 30mm Orthoscopic eyepiece. A dual-axis DC drive is optional. The Great Polaris mount can also be computer-driven with the addition of the optional Skysensor computer.

Celestron International, 2835 Columbia Street, Torrance, CA 90503, (310) 328-9560, fax (310) 212-5835. C8$^+$: $2,898; C8$^+$ Computerized: $3,798; GP-C8: $2,390; economy version of GP-C8 (without coatings and with 5x24 finder): $2,190; optional dual-axis DC drive for GP models: $450; Skysensor computer: $1,298.

2 The Starhunter 1 Telescope

Cusick Telescopes offers a complete Dobsonian telescope mount suitable for several brands of 12.5-inch f/5 mirrors and Coulter 13.1-inch mirrors, which the user supplies. The Starhunter features an 18-point air suspension mirror cell (with top-mounted collimation knobs) and a truss-tube assembly that splits in half at the center box section. Total weight of the telescope with focuser and Telrad finder (but without optics) is 56 pounds. A complete telescope with mirrors and 4-vane spider is also available.

Cusick Telescopes and Equipment Manufacturing Co., P.O. Box 256, Buena Vista, CO 81211, (719) 395-4818. Telescope without optics: $599; with 12.5-inch optics: $1,199.

3 The Twin-Beam Starlite II

This new version of the popular Starlite flashlight uses twin LEDs which can provide either a red beam for preserving night vision or a yellow beam for applications requiring a brighter light. The red LED is fully adjustable in brightness. An optional Velcro headband converts the Starlite into a headlamp.

Rigel Systems, 26850 Basswood Avenue, Rancho Palos Verdes, CA 90274, (310) 375-4149. Starlite II: $24.95; Headband: $8. Shipping extra.

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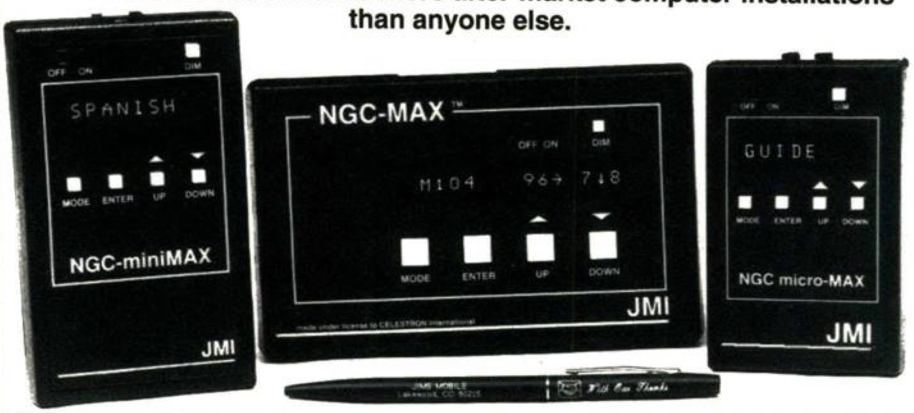

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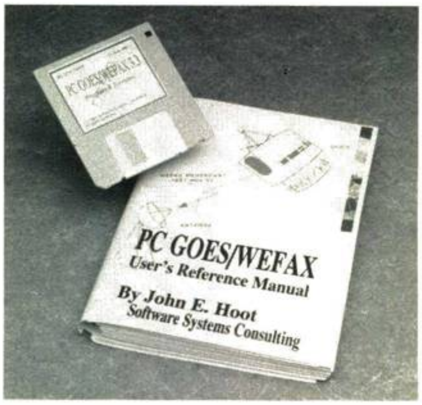

4

Software for Capturing Weather Satellite Images

The PC GOES/WEFAX 3.0 package includes a demodulator and image processing software that lets PC users display weather satellite images on their home computers. To pick up images from polar-orbiting satellites, the user needs a shortwave receiver with an IF bandwidth of 45kHz capable of receiving 137 MHz. Software Systems Consulting also offers suitable shortwave receivers, antennas, and complete ground stations for picking up geostationary weather satellites operating at 1691 MHz.

Software Systems Consulting, 615 S. El Camino Real, San Clemente, CA 92672, (714) 498-5784. $250.

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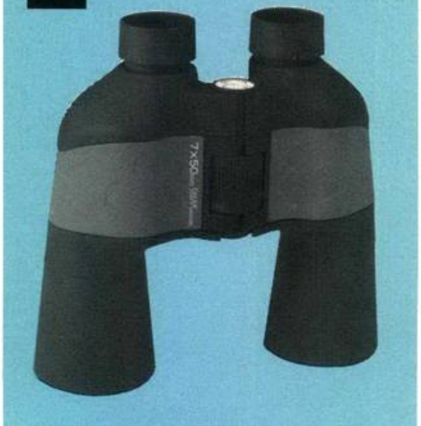
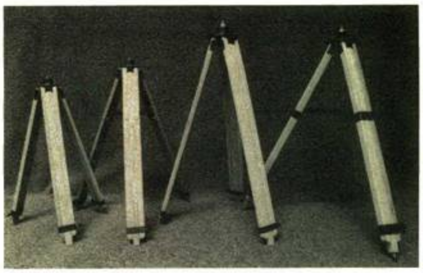


New Binoculars from Parks

The Parks 7x50 GR rubber-covered binoculars feature multicoated lenses, center focusing, light weight, and an ergonomic design. Dust caps, straps, and a soft-sided case are standard.

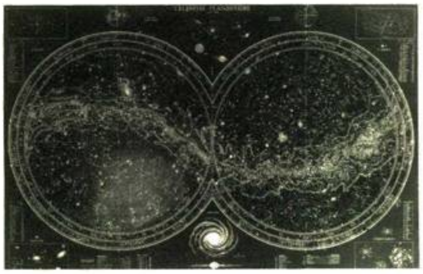
Parks Optical, 270 Easy Street, Simi Valley, CA 93065, (805) 522-6722. $250.



6 Wood Tripods from KB Systems

KB Systems' new tripods feature white ash hardwood legs and machined and cast aluminum heads. Metal parts are finished with a black epoxy wrinkle coating. The series includes (left to right) the KBBP Backpacker (weight 5.5 pounds, minimum height 29 inches, maximum 50 inches), the KBP1A (6.5 pounds, 34 to 60 inches), the KBP1001 (12 pounds, 40 to 67 inches), and the KBP1002 (10 pounds, 40 to 70 inches. Removable accessory trays are also available for all models except the Backpacker.

KB Systems, 10407 62nd Place West, Mukilteo, WA 98275, (800) 423-9677, fax (206) 355-8740. KBBP: $179.95; KBP1A: $199.95; KBP1001: $349.95 ; KBP1002: $249.95. Accessory tray: $39.95.



7 Celestial Planisphere Poster

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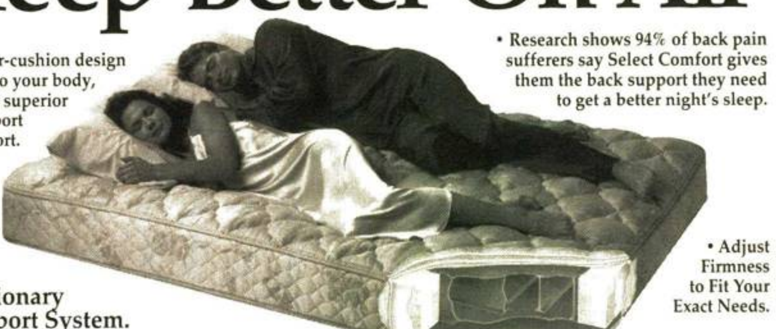

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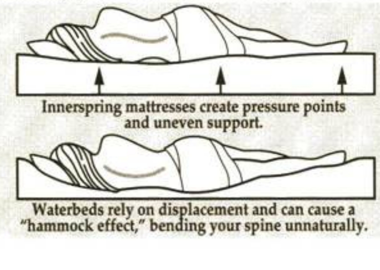

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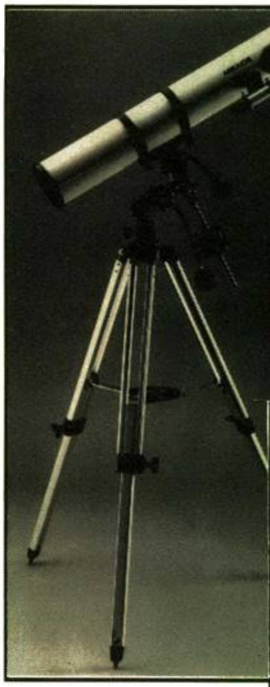

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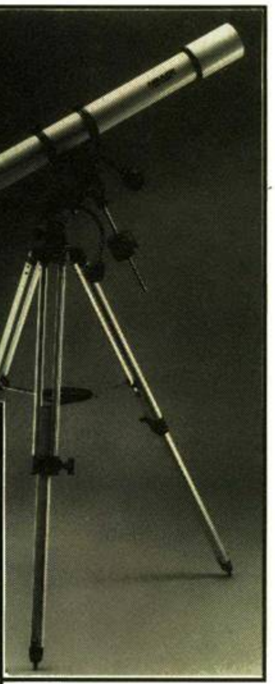

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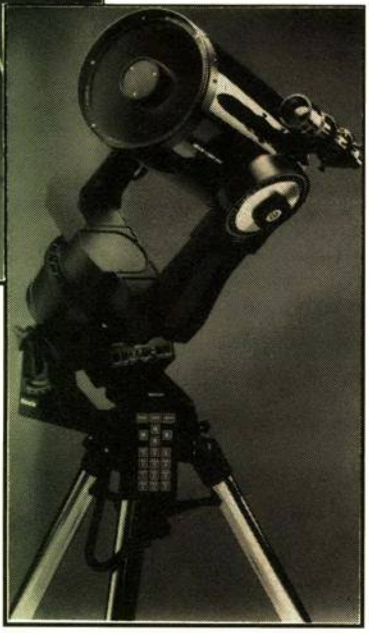

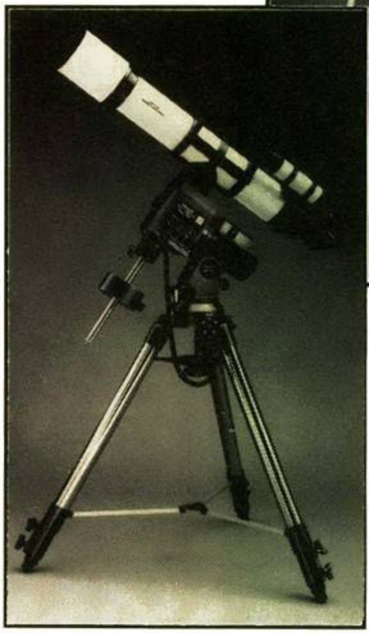

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Meetings & Events

September 25
Northern Indiana Astronomical Groups Fest '93, Camp Crossley, Warsaw, Indiana. Contact Thomas Nowicki, Michiana Astronomical Society, P.O. Box 262, South Bend, IN 46624, (219) 255-9492.

October 1-2
AstroAssembly 1993, North Scituate, Rhode Island. Hosted by Skyscrapers, Inc. and the Astronomical Society of Rhode Island. Contact Conrad Cardano, 68 Covingtown Road, Coventry, RI 02816.

October 7-9
4th Annual Twin Lakes Star Party, Golden Pond, Kentucky. Contact Jim Boren, West Kentucky Amateur Astronomy Club, (615) 232-6820.

October 7-10
3rd Annual Great Plains Star Party, Kansas Flint Hills, 75 miles SW of Kansas City. Contact Bob Nederman, 9200 Westbrooke Drive, Overland Park, MO 66214.

October 8-9
Bays Mountain Starfest, Kingsport, Tennessee. Sponsored by the Bays Mountain Park and Planetarium. Contact Adam Thanz, Bays Mountain Park and Planetarium, 853 Bays Mountain Road, Kingsport, TN 37660, (615) 229-9447.

October 12-17
Okie-Tex Star Party, Group Camp 3, Lake Murray, Oklahoma. Contact Clive or Beryl Cadle, Oklahoma City Astronomy Club, P.O. Box 21221, Oklahoma City, OK 73156, (405) 789-3742.

October 14-17
11th Annual Deep South Regional Stargaze, Percy Quin State Park, Mississippi. Sponsored by the Pontchartrain Astronomy Society, Inc. Contact Barry Simon, 820 Emerald Street, New Orleans, LA 70124, (504) 283-7592.

October 14-17
Chiefland Starfest, Chiefland, Florida. Contact Sparky Talios, Astro Scopers, Route #1, Box 302-C, Chiefland, FL 32626, (904) 493-4359.

October 15-16
All-Arizona Star Party, 15 miles south of Arizona City, Arizona. Contact Ted Heckens, East Valley Astronomy Club, 1836 N. Stapley Drive #100, Mesa, AZ 85203, (602) 827-1524.

October 15-16
Astronomy Festival '93, Vestal, New York. Sponsored by the Kopernick Astronomical Society. Contact Jay Edwards, Kopernick Space Education Center, Underwood Road, Vestal, NY 13850, (607) 748-3685.

October 15-17
15th Annual Astronomy Jamboree, Southold, New York. Contact Barbara Lebkuecher, Custer Institute Observatory, Box 1204, Main Bayview Road, Southold, NY 11971, (516) 722-3850.

October 15-17
Cosmos '93, Timberline Lodge, Mt. Hood, Oregon. Contact Robert McGown, 2535 S.W. Palatine Street, Portland, OR 97219, (503) 691-0077.

October 15-17
Stella-Della-Valley VII, Ottsville, Pennsylvania. Sponsored by the Bucks-Mont Astronomical Association. Contact Ed Melnick, 1443 Devon Road, Warminster, PA 18974, (215) 443-7929.

October 16
Autumn Star Party, Portsmouth, Virginia. Sponsored by the Tidewater Community College Planetarium Society. Contact R.H. Stewart, 1064 Dune Street, Norfolk, VA 23503.

October 16
Blue Ridge Parkway Regional Stargaze (Part 2), Julian Price Park, 4.5 miles south of Blowing Rock, North Carolina. Contact Greg Kirby, Catawba Valley Astronomy Club, Route 3, Box 472, Granite Falls, NC 28630, (704) 396-7656.

October 20-23
29th Annual Conference of the Great Lakes Planetarium Association, Dayton, Ohio. Sponsored by the Great Lakes Planetarium Association. Contact Art Goss, Museum of Natural History, 2600 DeWeese Parkway, Dayton, OH 45414, (513) 275-7431.

October 22-24
2nd Annual Convention of the Antique Telescope Society, Williams Bay, Wisconsin. Sponsored by the Antique Telescope Society. Contact Walter H. Breyer, 30 Green Valley Road, Wallingford, PA 19086. ☐

Clubs, please indicate the city and state where your meeting will be held, and submit your announcements at least four months prior to the event. Readers, include a self-addressed, legal-sized envelope with your request for information.

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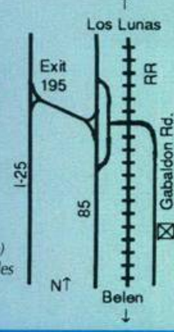

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Readings & Credits

Mars: The Russians Are Going! (page 26)

Mars, by Hugh H. Kieffer et al., editors, (University of Arizona Press, 1992). Compilation of technical papers summarizing our current knowledge about Mars. Contains chapter by Conway Snyder and Vassili Moroz that provides the history of American and Russian Mars probes.

Seeing a Star's Surface (page 34)

"Unfolding Mysteries of Stellar Cycles," by Sallie Baliunas and Steven Saar, ASTRONOMY, May 1992. Describes stellar activity cycles and how stars generate magnetic fields.

Jove's Hammer (page 38)

The Planet Jupiter, by Bertrand M. Peek, (Faber, 1981). The classic observer's guide to Jovian phenomena.

Introduction to Observing and Photographing the Solar System, by Thomas A. Dobbins, Donald C. Parker, and Charles F. Capen, (Willmann-Bell, 1988). An excellent modern guide to planet viewing.

Moons and Planets, by William K. Hartmann, (Wadsworth, 1993). The best introduction to planetary science available.

In the Beginning (page 40)

The New Cosmos: The Astronomy of Our Galaxy and Beyond, (Kalmbach Books, 1992). An overview of galactic and extragalactic research that contains substantial material on globular clusters and the age paradox.

Over the Edge (page 56)

Galaxies, by Timothy Ferris (Sierra Club Books, 1980). A pictorial tour of the universe of galaxies, including many odd and distant objects. Nicely illustrated with color imagery and diagrams outlining the distance scale of the universe.

Galaxies and the Universe: An Observing Guide from Deep Sky magazine, edited by David J. Eicher, (Kalmbach Books, 1992). A reprint volume of the best articles on galaxies from the now defunct *Deep Sky* magazine. Contains data tables, photos, and sketches of challenging objects.

Cool Sharp Nights (page 70)

Burnham's Celestial Handbook, by Robert Burnham, Jr., (Dover, 1978). A massive three-volume set that includes data and observational descriptions for deep-sky observers armed with either refractors or reflectors.

Stars and Galaxies: ASTRONOMY's Guide to Exploring the Cosmos, edited by David J. Eicher, (Kalmbach Books, 1992). Articles culled from ASTRONOMY that highlight 400 deep-sky objects visible to backyard observers.

Cover: Michael Carroll; ***p. 4:*** Michael Carroll; ***p. 13:*** Keith Ward; ***p. 18:*** NASA/JPL; ***p. 22, top:*** IBM Research and Smithsonian Astrophysical Observatory; ***bottom:*** JPL/NASA; ***p. 24, top:*** Ben Frank; ***bottom:*** Alan Dyer; ***pp. 26-27:*** Michael Carroll; ***pp. 28-33:*** Phil Kirchmeier; ***p. 34:*** courtesy of Klaus Strassmeier; ***pp. 35-36:*** courtesy of Steve Vogt; ***p. 36, top:*** courtesy of Steve Saar; ***p. 37:*** courtesy of Artie Hatzes; ***p. 38:*** Michael Carroll; ***p. 39:*** JPL/Paul Chodas; ***pp. 40-45:*** Bob Eggleton; ***p. 48:*** Seth Horowitz, 135mm f/2.8 lens, Tri-X film, 23-second exposure; ***p. 56:*** Jack Newton, 25-inch f/5 reflector, ST-6 CCD camera; ***p. 57:*** Jack Newton, 25-inch f/5 reflector, ST-6 CCD camera; ***pp. 58-59:*** Martin C. Germano, 14.5-inch f/5 reflector, hypersensitized Tech Pan film, 90-minute exposure; ***p. 59, top:*** Jack Newton, 25-inch f/5 reflector, ST-6 CCD camera; ***bottom left:*** James R. Foster, 14-inch SCT at f/11.5, hypersensitized Tech Pan film, 195-minute exposure; ***bottom:*** David Healy, 14-inch SCT at f/7, hypersensitized Tech Pan film, 60-minute exposure; ***p. 60, top:*** Jack Newton, 25-inch f/5 reflector, ST-6 CCD camera; ***bottom:*** Martin C. Germano, 8-inch reflector at f/6, hypersensitized Tech Pan film, 90-minute exposure; ***p. 61:*** Jack Newton, 25-inch f/5 reflector, ST-6 CCD camera; ***pp. 64-69:*** equipment photos by Darla Gawelski; ***p. 68, top and bottom left:*** Alan Dyer; ***p. 70:*** Mace Hooley; ***p. 71, top:*** Bill and Sally Fletcher; ***bottom:*** D. B. Jamison; ***p. 72, top:*** Michael Stecker; ***bottom:*** Jack Newton; ***p. 73:*** Lee Coombs; ***pp. 74-77:*** Darla Gawelski; ***p. 81 top:*** Lin Ben Chu, 560mm lens at f/4, Fuji 400G film, multiple exposure on June 4, 1993, from Kenting National Park, Taiwan, Republic of China; ***center:*** Joe Myers, 8-inch SCT at f/6.3, Fuji NHG 135 film, 80-second exposure on June 4, 1993; ***bottom:*** Ernie Piini, May 21, 1993; ***pp. 82-83 top:*** Paul Moeller, 5.6-inch refractor at f/7, Ektar 25 film, 1/1000-second exposure on May 21, 1993, from Goldendale, Washington; ***p. 82, center:*** Ken Williams, 16-inch f/5 reflector, hypersensitized Tech Pan film, 60-minute exposure on March 25, 1993; ***bottom left:*** Don Parker, 16-inch reflector and SpectraSource Lynnx CCD camera, taken on May 15, 1993; ***bottom right:*** Henry Walker, taken on May 21, 1993, from La Mesa, California; ***p. 83, bottom:*** Jacques Guertin, 5-inch Maksutov at f/18, 100 ISO film, 1/125-second exposure on May 21, 1993; ***p. 86:*** Darla Gawelski; ***p. 100:*** Jacques Guertin.

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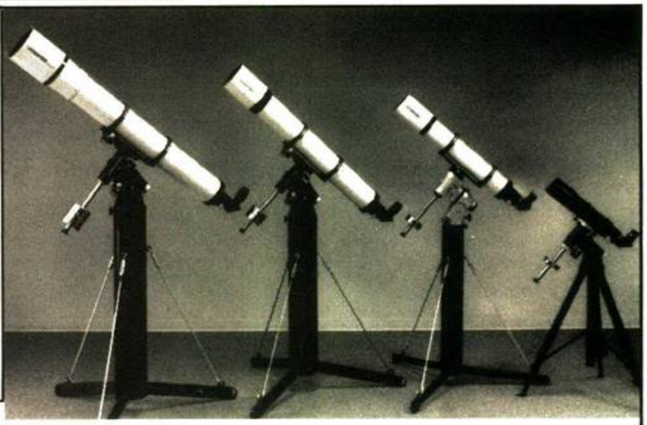

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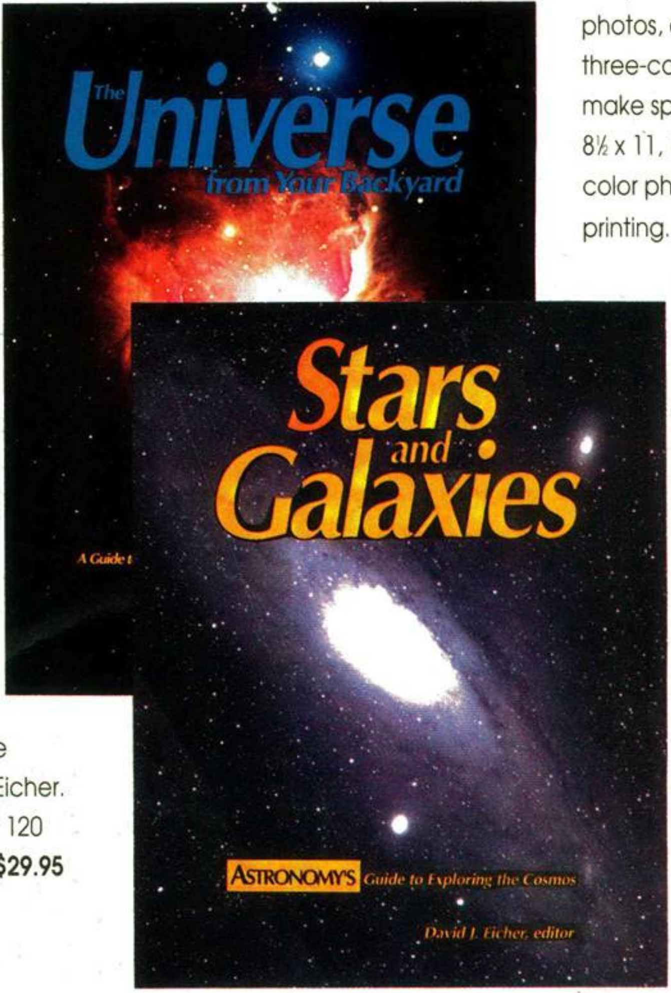
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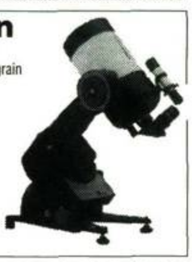

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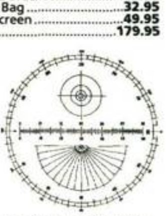

Features a laser-etched reticle **with built-in cordless illuminator** with adjustable brightness control. The eyepiece is a MC 12.5mm Orthoscopic that can easily be viewed even with eyeglasses. Guiding with conventional dual-crosshair reticles often forces the user to slightly defocus the guide star to prevent it from suddenly being "hidden" behind the broad grooves - greatly reducing the limiting magnitude. Due to the finely etched lines in the Micro Guide, much fainter, sharply focused stars can be "captured" as guide stars with no reduction in limiting magnitude. **143.95**

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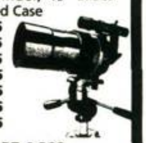

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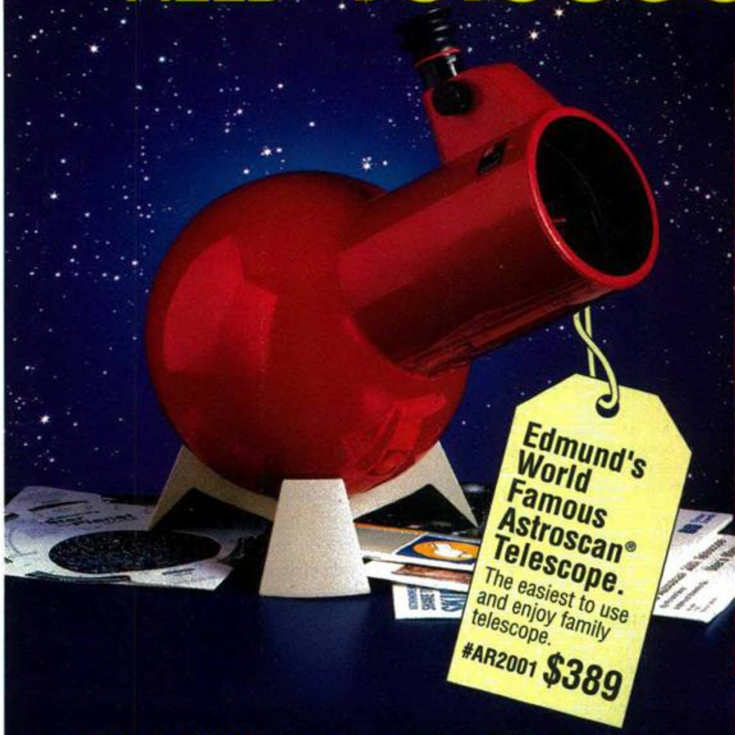

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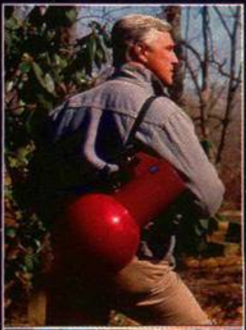

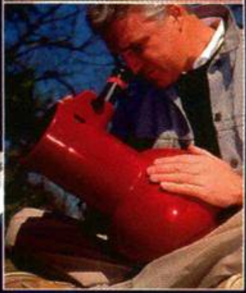

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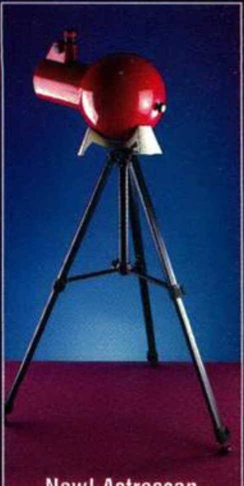

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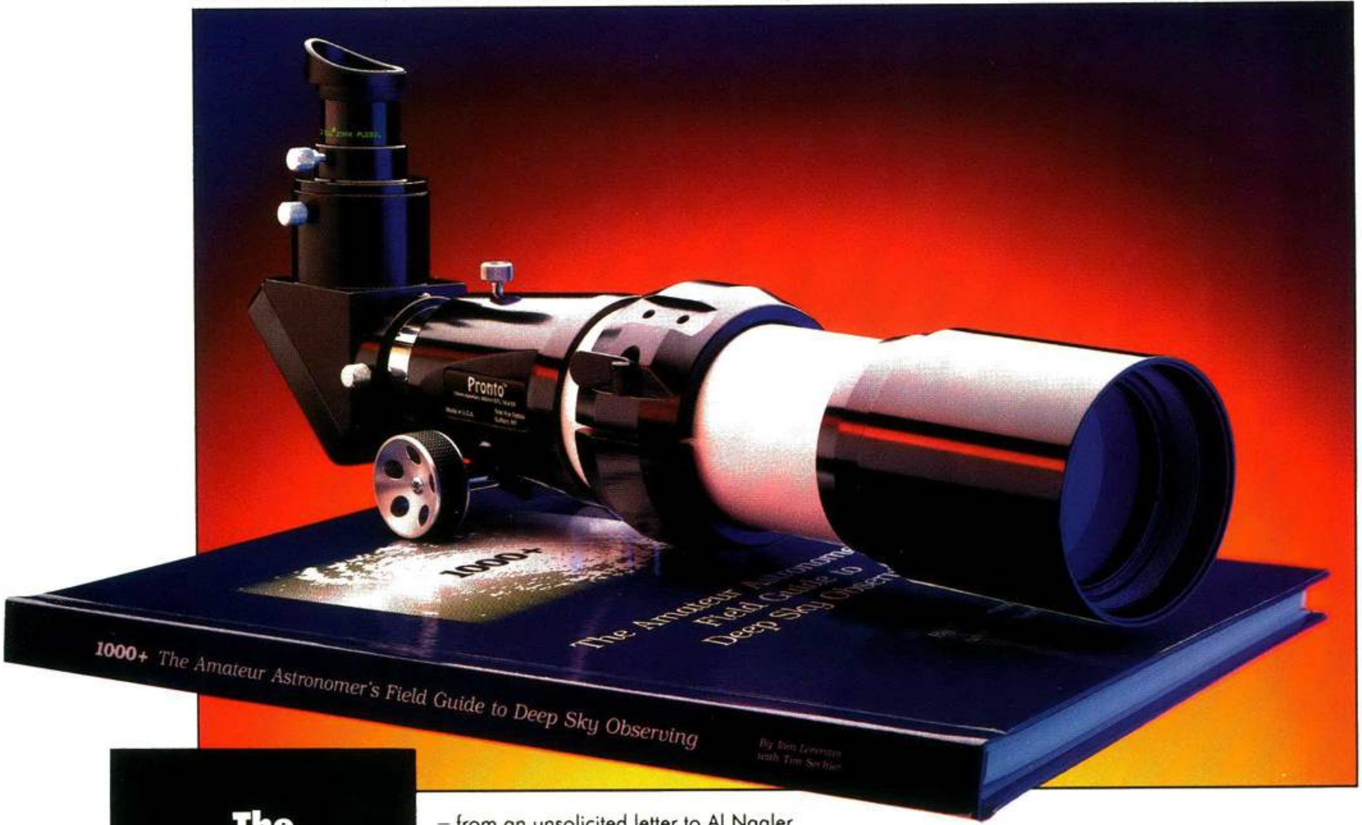
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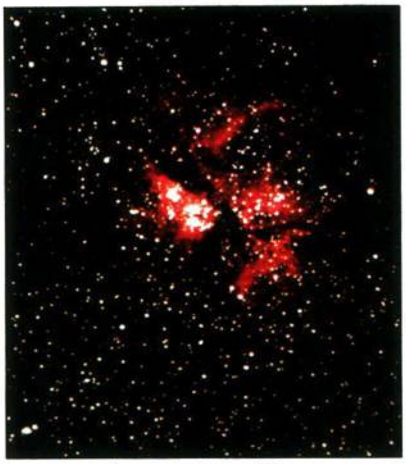
– from an unsolicited letter to Al Nagler

"Since I've been singing the praises of my Pronto to several people, I figure I'd better send you another note. During the November dark run, I used the Pronto on all or part of three nights. I made observations of 72 objects including a few double stars. Most of these observations were on a single night where the seeing was a little soft for the 6-inch refractor, but hardly noticeable in the Pronto. For me, the instrument's relative insensitivity to seeing is a great advantage, allowing good observing on nights I otherwise wouldn't go out.

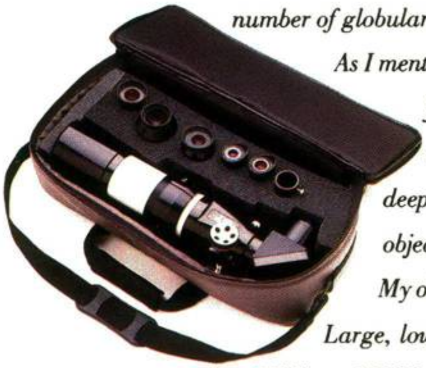
The limiting stellar magnitude is between v=13.5 and v=14.0. This limiting magnitude is faint enough that a substantial number of globular clusters will be at least partially resolved.

As I mentioned before, the 30x eyepiece is my favorite for sweeping the Milky Way. I ended up using 50x for larger objects; 75x for 'ordinary' deep-sky viewing. A few high surface brightness objects were viewed to advantage at 110x, & I used 150x on double stars.

My observations show that from a true-dark site, the telescope is a real performer. Large, low surface brightness objects are routinely visible; even I was surprised by the visibility of NGC 147. Using the stars plotted on Uranometria, I traced the Andromeda galaxy to 4° length on two nights." – Brian Skiff, Author & Astronomer



Pronto photo of Eta Carina by Ralph Sieger



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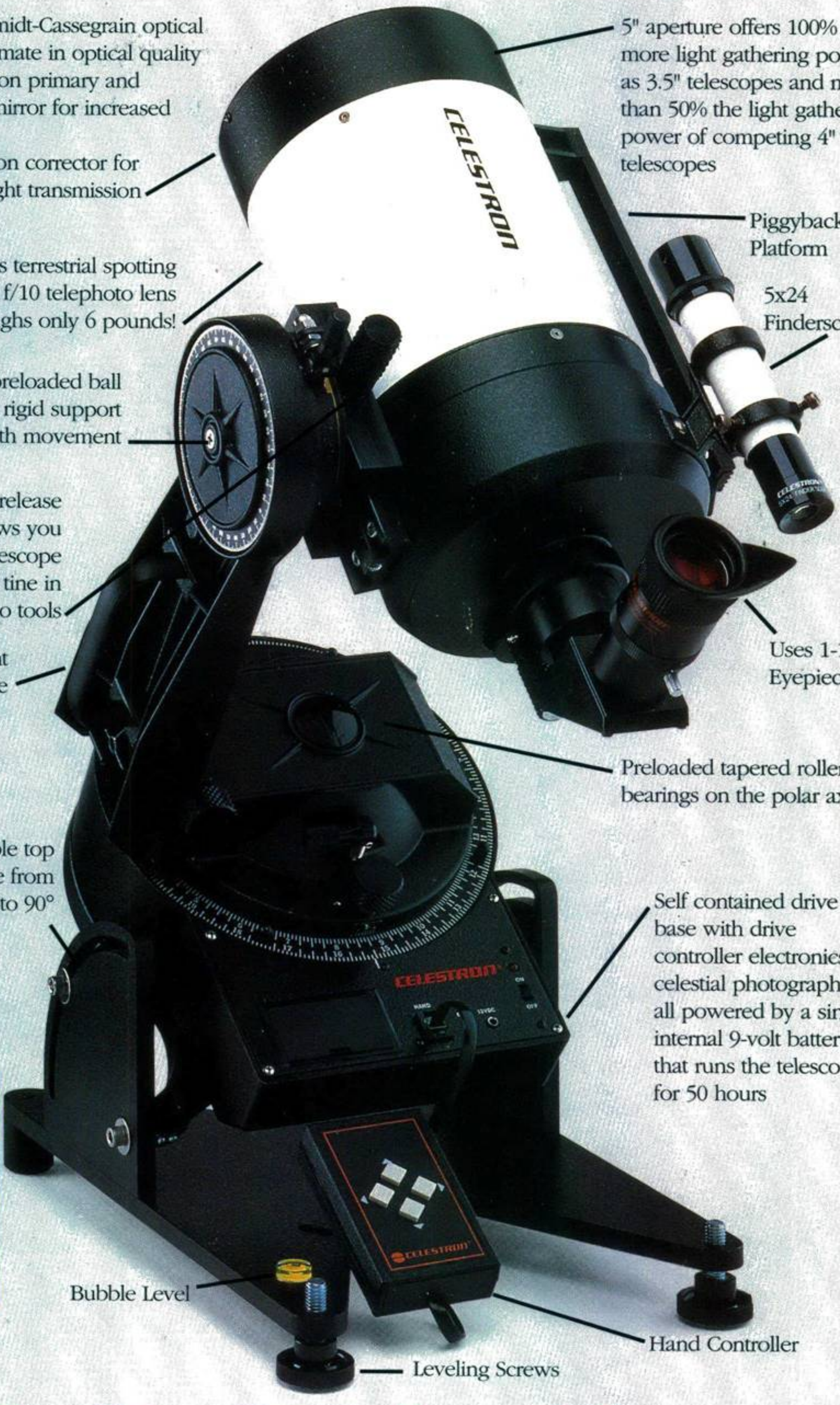

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